ESTUDIOS e INFORMES de la CEPAL

77

THE WATER RESOURCES OF LATIN AMERICA AND THE CARIBBEAN — PLANNING, HAZARDS AND POLLUTION

UNITED NATIONS

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INTRODUCTION

Following the United Nations Water Conference held in Mar del Plata, Argentina in 1977, ECLAC was charged with reporting on the application of the Mar del Plata Action Plan. This volume of papers is such a report and provides a review of developments in areas of water resource management in Latin America and the Caribbean. The prime purpose of these reviews is to provide water managers in the region with an insight into developments in water management in countries other than their own and to provide a comparative evaluation of the different national experiences. At the same time, for those outside the region, the intention is to provide a summary of water management developments not available elsewhere.

This book contains three reviews: on the formulation of national water resource plans, on water-related natural hazards, and on water pollution. These particular subjects were chosen because little information was available on them previously. They are also topics of particular interest at the present time. Further reports are in preparation, including an Atlas of water resources and their use, a survey of the financing of investments in the water sector, and a report on the education and training of professionals and technicians. In addition, an evaluation is planned of the progress achieved in the region in the provision of drinking water supply and sanitation during the International Drinking Water Supply and Sanitation Decade.

Present trends in water resource use

Despite the severe economic crisis that has affected the region during most of this decade, the use of the region's water resources has continued to intensify, although not at the rate estimated during the 1970s. The major demands remain those for water supply, for irrigation and for the generation of hydro-electricity.

The continual growth of the population and emigration to the cities are the main factors impelling the increase in both the demand for drinking water and the use of the water resource for the transportation of wastes. The growth of the population served with drinking water supply and sanitation has not been as fast as was anticipated at the beginning of the decade (figure 1), but in contrast the expansion of demand has been notable.

Over the last twenty years, the area of cultivated land under irrigation has increased by three-quarters, and in some countries —particularly in the Caribbean and Central America— the area has grown much more than this (figure 2).

The installed capacity in hydro-electricity has continued to grow during this decade both absolutely and relatively as a proportion of the total installed electricity generating capacity (figure 3). Expansion in capacity has been largest in the bigger economies, although some of the smaller countries show the fastest relative rates of growth.

The result of the growth of water use is increasing control over patterns of flow of the water resource. Even now, however, the pattern of water use in Latin America and the Caribbean remains characterized by a heavy concentration in coastal areas, with only limited impact on the flows of the major drainage systems. The major human influence on patterns of flow continues to be land use, but the deliberate regulation of flows is growing in significance.

Given these characteristics of contemporary water use, the relevance of the three subjects treated in these reviews is obvious. The increasing intensity of use demands adjustment of management institutions and methods, and the formulation of management plans is one means of introducing such change. The losses from water-related natural disasters have increased as human activities have multiplied and become more capital-intensive, while the increasing concentration of population and the growth of industry have brought in their train the pollution of the region's water resources.

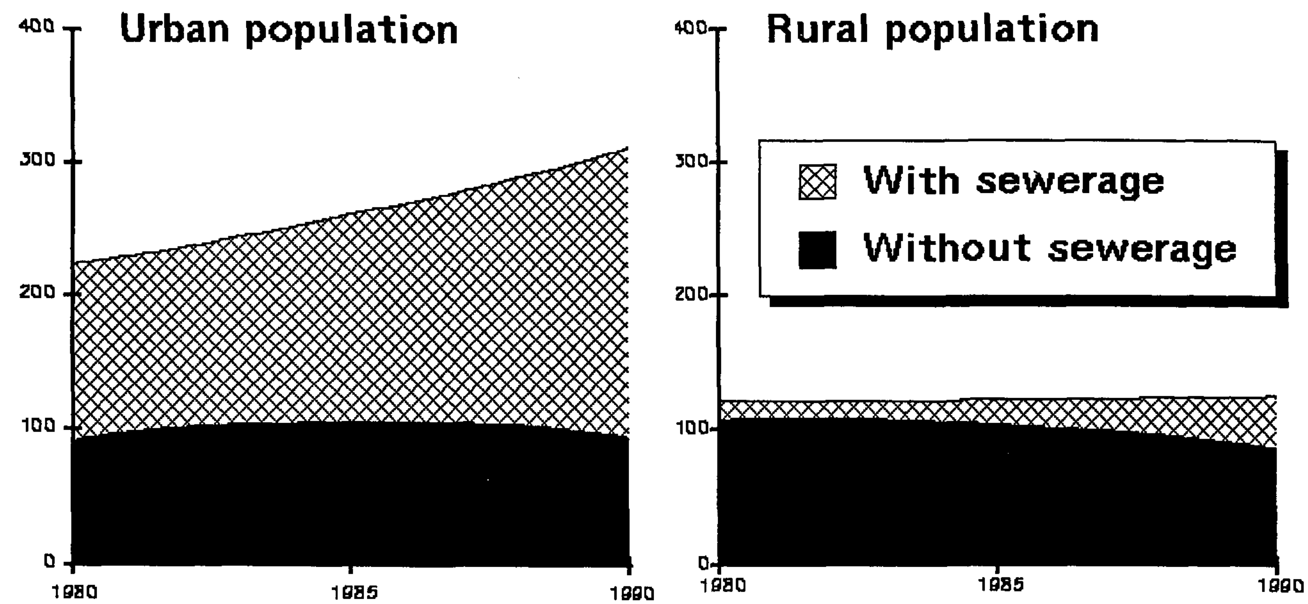
FORMULATION OF WATER RESOURCE MANAGEMENT PLANS

This study examines the formulation of plans for water resource management in Latin American and the Caribbean countries, in order to explore the prospects of an interchange of experiences in the field of water management within the region.

The study is based on a comparative analysis of a number of water resource management plans at different stages of formulation, both national and regional. The documents analysed come from Brazil, Colombia, the Dominican Republic, Ecuador, El Salvador, Honduras, Jamaica, Mexico, Peru and Venezuela. The aim has been to

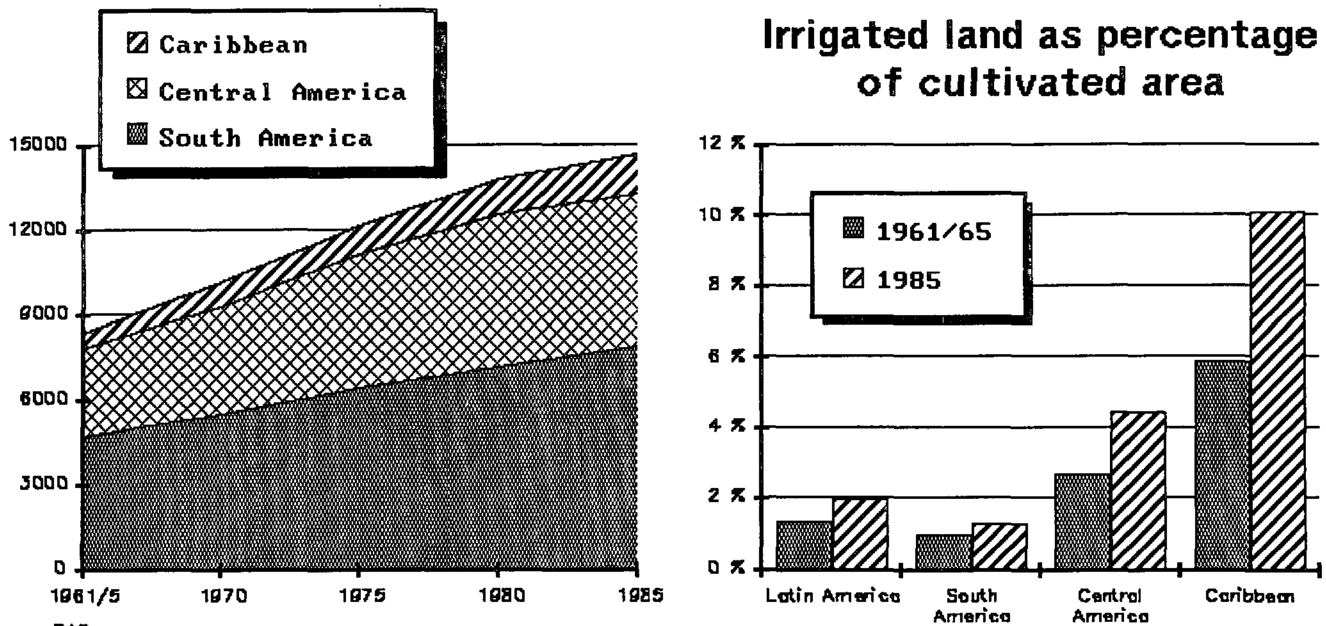
Figure 1

POPULATION SERVED BY SEWERAGE IN 26 LATIN AMERICAN AND CARIBBEAN COUNTRIES (millions)



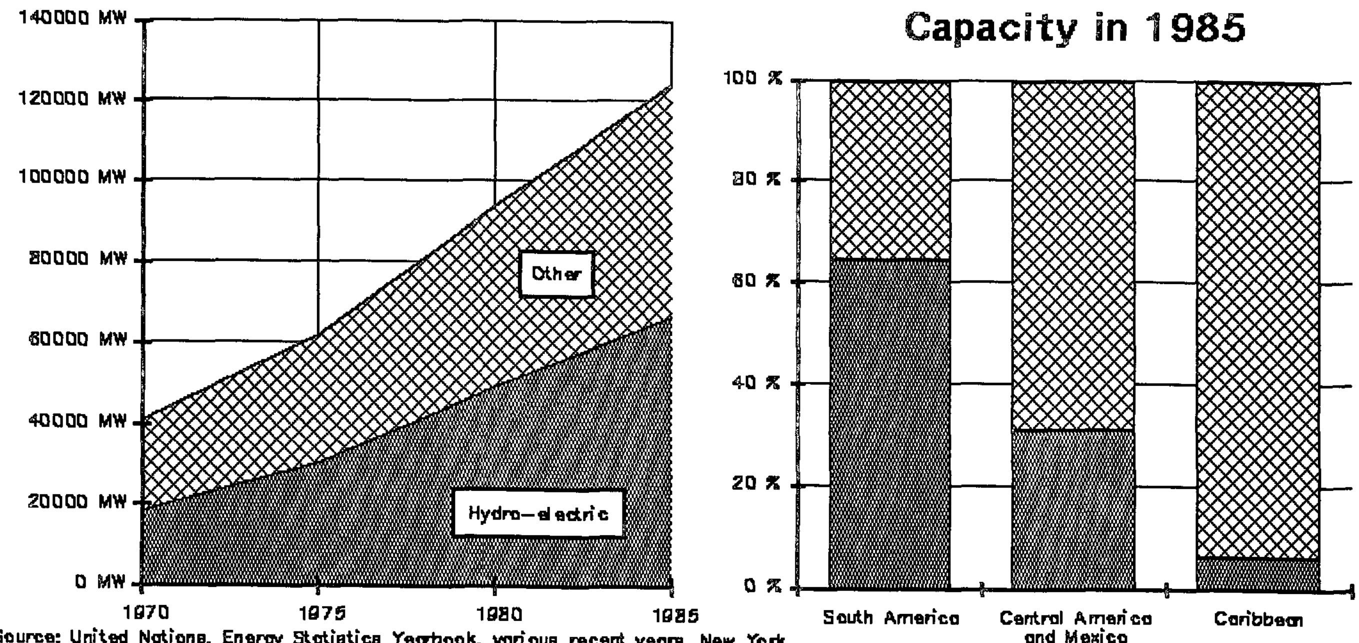
Source: PAHO.

Figure 2
LATIN AMERICA AND THE CARIBBEAN: LAND UNDER IRRIGATION (thousands of hectares)



Source: FAO.

Figure 3
NET INSTALLED CAPACITY OF ELECTRIC GENERATING PLANTS, BY TYPE, 1970-85



Source: United Nations, Energy Statistics Yearbook, various recent years, New York.

compare plans relating to the multisectoral use of water, although the report also reviews a number of sectoral plans, mainly in relation to population, energy and agriculture.

The analysis shows that the countries of the region which have undertaken the formulation of national water management plans follow or have followed a similar methodology of work. This methodology includes the territorial regionalization of the water resource, the calculation of the supply and demand for water by regions, and the formulation of technical and administrative strategies to harmonize water requirements and availability. There is, however, an appreciable difference in the progress made in each country, owing to the years of difference in the initiation of the plans, the different ecological/environmental conditions prevailing in each country, and the different modes of work and other factors, all of which indicate that there is considerable potential for an interchange of ideas on the subject.

An effort has been made to determine the relative usefulness of the formulation of plans, the way in which socioeconomic development plans are related to those for water development, and the form in which plans of national scope are linked with those applying to regions and to river basins. The study includes an analysis of the way in which water resource plans incorporate the environmental dimension. No attempt has been made, however, to evaluate the form in which plans, once completed, have been or are intended to be put into practice.

From the main observations made in the text, it can be said that on the whole the formulation exercise has been useful in the countries which have undertaken it. The chief benefits obtained include: a better knowledge of the availability of water in these countries and in their respective regions; better interinstitutional co-ordination with regard to water; a better knowledge and increased creation of alternatives for the harmonizing of water supply and demand; a better perception of the current and potential conflicts concerning water exploitation; a better prospect of incorporating environmental considerations, and —almost immediately— a large number of options for improving the operation of the water systems already constructed.

The conclusions indicate that the formulation of plans enables the countries to develop water policies in accordance with their socioeconomic development goals, although there is certainly no guarantee or compulsion that these policies will be realized or taken into account in the decision-making process.

WATER-RELATED NATURAL HAZARDS

This report provides a review of the regional situation in respect of water-related natural hazards. It includes a discussion of the characteristics of the water-related natural hazards that affect Latin America and the Caribbean, recent experience of disasters caused by such hazards, their effects on social and economic development and the environment, and the disaster-mitigation measures adopted in the region.

Many areas of Latin America and the Caribbean are prone to natural hazards arising from extreme events related to water. The countries of South America are most frequently affected by floods and flood-induced land and mudslides. In contrast, in Central America and the Caribbean the severest natural disasters are usually tropical cyclones. In addition, many areas in all parts of the region are affected by droughts which sometimes last for several years.

Water-related natural disasters inflict heavy damage on the region's economy and cause numerous deaths. Unfortunately, there has been no systematic evaluation of this impact, but a comprehensive picture can be built up from individual examples. In 1979, the hurricanes David and Frederick led to more than 1 400 deaths and caused damage estimated at US$830 million or 16% of GDP in the Dominican Republic. In 1982-1983, a combination of extensive flooding in the coastal areas and extreme drought in the highlands in Bolivia, Ecuador and Peru caused total damage estimated at US$3 478.9 million or 8.5% of GDP. In 1985, a mudslide set off by the eruption of the Nevado del Ruiz volcano in Colombia killed over 23 000 people and injured 5 000 others. In all, in recent years, water-related natural disasters have caused damage estimated at US$11 billion or 1-2% of the region's annual GDP. The devastating effects of natural disasters show a tendency to increase. Several factors contribute to this. In the region the process of population growth and migration of population to cities and other areas of relatively higher risk continues. Population growth is accompanied by increased capital investment and construction of dwellings and other structures in hazardous areas. Finally, the severity of certain water-related disasters has increased due to the man's negative influence on his environment.

The extent of the damage caused by natural disasters in Latin American and Caribbean countries can be reduced by mitigation measures. Structural measures are most frequently used to protect from floods. To reduce the impact of droughts, efforts have been concentrated on improving the availability of water through storage or through the tapping of groundwater. Attention has also been paid to more efficient utilization of water and unconventional water sources. Construction of breakwaters and sea-walls helps mitigate the impact of storms. Structural measures are usually highly capital intensive, however, so that their wider utilization is hampered by the lack of financial resources. Non-structural measures adopted in Latin America and the Caribbean include warning systems, emergency measures, land-use controls and building regulations. Regional forecasting and warning measures are particularly important in the Caribbean and Central America, where the Hurricane Committee co-ordinates national and regional activities related to early hurricane warning and flood forecasting. There is also substantial co-operation in flood forecasting in the River Plate basin, in tsunami warnings in the Pacific and in drought forecasting. Emergency measures, including development of emergency legislation and plans, construction of Disaster Centers, etc., have been adopted to a limited extent. Land use planning measures are applied only in isolated cases within urban areas, although their use is growing. Building regulations are also used in the region as a disaster-mitigation measure, but their impact is limited.

WATER POLLUTION

One of the salient features of the use of the water resources of Latin America and the Caribbean in the second part of the twentieth century has been the emergence of pollution as a significant and alarming problem of many water bodies. Locally, it is a problem that has already reached critical proportions. The most important factors accounting for the increase in pollution include rapid population growth, improvement in the provision of drinking water supply and sewerage services, the expansion of industry and the technification of agriculture —all this unaccompanied by corresponding development of waste treatment facilities and pollution control.

Despite the significance assumed by water pollution in the region, there has been no systematic evaluation of its evolution, its impact on the welfare of the population or its economic consequences. The overall effect of water pollution on water resources is also not known. This report is an attempt to fill this gap through a descriptive survey based on existing reports and information, aimed at providing an overview of the growing water pollution problems and the measures adopted by countries to combat them.

The main sources of water pollution in the region are direct discharges of domestic sewage and industrial effluents, with the general cause of pollution being the overall absence of wastewater treatment plants for any but the most toxic industrial wastes. As a result, virtually all effluents are discharged into the nearest water bodies without any treatment. Available information suggests that it is domestic sewage which causes particular health concern. At present, many water bodies, particularly near large urban areas, are heavily contaminated. Recent studies indicate that, on average, faecal coliform contamination is likely to be higher in Central and South American rivers than in other regions of the world. The major industrial waste loads in the region come from the pulp and paper, chemical, petrochemical, petroleum refining and metal-working industries, food processing and textiles. Pollution from mining and petroleum production also affects many rivers and some coastal areas, with pollution from mining being particularly acute in the Andean countries. An important and growing source of pollution is the use of fertilizers and toxic chemicals in agriculture, although their consumption in the region continues to be substantially lower than in developed countries. Pollution by such products is frequently aggravated by significant local abuses in their use and improper application owing in part to the lack of knowledge of soil management techniques.

Water pollution has a significant effect on the welfare of the population and, to a lesser extent, on the economic development of the Latin American and Caribbean countries. The pollution of surface waters by domestic sewage poses serious health problems, particularly to the urban population, in many countries. It is generally accepted that the high rate of infant mortality and the incidence of various intestinal infectious diseases can be attributed at least partially to the pollution of water bodies by human wastes. There are indications that contamination of water bodies in different parts of the region by agricultural chemicals and industrial effluents also represents a hazard for human health. A serious problem is the use of contaminated water for irrigation. Groundwater, which in many areas it is an important source of drinking water and of water for irrigation, is also increasingly affected by pollution.

In the last decade the countries of Latin America and the Caribbean have adopted various measures, including laws to control pollution, water quality monitoring and the wider adoption of wastewater treatment, with the aim of remedying water pollution problems. Many countries seem to possess well-prepared water pollution control legislation but it frequently falls far short of achieving its objectives in practice. Adequate water quality monitoring networks are still rare, and because most effluents are discharged without any treatment the monitoring of wastewater quality is also limited. Nevertheless, measurement and studies of surface and groundwater quality have made considerable advances in the region. Because of the high costs and other problems related to the introduction of wastewater treatment several countries have centered their efforts on the development of relatively simple and low-cost waste treatment techniques such as stabilization ponds and methods based on the use of local products.

On the whole, while not denying the advances made in the region towards reducing water pollution, the Latin American and Caribbean countries continue to face a steady decline in the water quality of many water bodies, and because of inadequate financial resources, weak implementation of existing legislation and the generalized attitude that preservation of water quality is only a secondary priority, efforts to arrest this decline are still no more than incipient.

Part One

THE FORMULATION OF WATER RESOURCE MANAGEMENT PLANS *

* This document was published by ECLAC under the symbol LC/G.1391 on 1 April 1986.

Introduction

The importance of planning as a basis for accelerating economic and social development has been a subject of debate since the end of the 1940s.[1] The purpose of the present study is to make a preliminary assessment of Latin American experiences in the planning of the utilization and management of water resources in order to: a) decide if it would be justifiable to make a serious attempt at horizontal co-operation, by assessing the existing relations between efforts and decisions in the planning field with regard to the allocation of resources to the water sector and the decisions made on the management (or utilization) of water and allied resources, parts of which depend the attainment of the development goals established in the plans; and b) define the scope of a co-operative effort between national institutions engaged in the planning, management and use of water resources.

The advocates of water resource planning maintain that it is the only way to achieve an integrated approach to the utilization and management of a resource which can satisfy several objectives and be used for multiple ends. Planning enables the long-term reciprocal influences of physical and socioeconomic systems to be taken into account, and thus provides the bases for a flexible management to cope with uncertainty and reduce traditional external effects (environmental repercussions) so as to obtain greater and more sustained economic services from the system of water and related resources. Planning permits the co-ordination of a multiplicity of institutions involved in the exploitation of natural systems (river basins) in which water is a central element, and this in its turn leads to the application of the integrated and flexible decision-making process outlined above.

The sceptics think that the planners of water use overlook the politico-institutional and socioeconomic realities which guide the actual decisions on public resource allocation and the way in which water is used. Hence the plans reflect a technocratic opinion expressed in ideal draft projects which have no relation to the real decision-making process and are therefore not functional. Although these opinions for and against may seem exaggerated they are contrasted in this way in order to elucidate the issues that must be considered.

Evolution of and perspectives for water resource planning *in Latin America and the Caribbean*

It is premature to express opinions on the future of the planning of water resource management in Latin America and the Caribbean, but there is a clear trend in all the countries towards the formulation of increasingly complete and long-term plans.

Originally, the common trend in the countries of the region was to plan water resources by user sector, especially irrigation, energy generation and the supply of drinking water. Frequently these plans did not form part of national or regional development plans, their sole purpose being to give priority to investments in water projects without taking into account other aspects, such as "to incorporate the environmental dimension" in the designing and operation of the projects and in particular to promote the multiple utilization of water resources.

Neither were territorial spaces clearly defined in these plans. The use of water was planned in response to administrative rather than hydrographic limits and it was uncommon for hydrographic basins to be considered as the basis for an integral planning of the utilization of water.

The main problems in the management of water systems in Latin America and the Caribbean are as follows: a) the difficulty encountered in the operation and maintenance of constructed works and the management and conservation of the natural resources included in the project areas; b) the excessive sectoralization of activities in the field of water; c) the scant attention paid to social and environmental considerations generated by the project in general; d) the difficulty of sustaining and giving priority to the large investments required for the utilization of water resources; e) the scant attention paid to the use of water in rainfed zones in the agricultural sector.

In order to solve these problems the countries of the region have decided to seek different options for the management, co-ordination and integration of activities associated with water resources. At the outset it was usual to set up commissions formed by representatives of various sectors using water resources. When these commissions became permanent, and ceased to solve possible emergencies, they were gradually transformed into an instance of interinstitutional consolidation. The best-known case is that of Mexico, which in 1926[2] formed the National Irrigation Commission, in conjunction with the enactment of a specific law on this priority aspect of water use. At the beginning of 1947, the National Irrigation Commission was raised to the category of Secretariat and there came into being what was then known as the Secretariat for Water Resources (Secretaría de Recursos Hidráulicos) (SRH), today designated the Secretariat (i.e., Ministry) of Agriculture and Water Resources (SARH). In 1950 there began to appear river basin projects for multiple purposes and subsequently in 1972[3] the Commission for the National Water Plan was set up.

In the case of Mexico, the driving and cohesive factor which stimulated the creation of a national water plan was the need to plan the use of irrigation water, owing to the large investments required for this purpose. In other countries, and in line with their particular features, the priority uses have been linked with energy generation, the provision of a drinking water supply and navigation, together with the need to control the quality of water and such phenomena as floods or droughts.

The geographical area of action of these institutions was in accord with these sectoral purposes and frequently their activities were conducted only in certain parts of the territory of a country or in the area of a basin. More recently, however, these limits have been far exceeded in respect of water resource management. Thus, in addition to national plans and individual basin plans, there are binational and multinational plans comprising the integral management of the large basins, as for example the River Plate Basin, with the creation of the Intergovernmental Committee of the Countries of the River Plate Basin (CIC). These advances have been associated with an improvement in the co-ordination of interinstitutional activities and in water legislation.[4]

These facts serve to show that on some fronts which foster the development of an adequate policy in the field of water utilization, such as planning, management, integration, interinstitutional co-ordination, legislation on water resources and financial negotiation, important progress has been made in Latin America and the Caribbean, and every effort to facilitate this progress will therefore benefit the countries of the region. The nature of these aspects is analysed in the present study.

A. REFERENCE FRAMEWORK FOR THE FORMULATION OF NATIONAL PLANS FOR THE MANAGEMENT OF WATER RESOURCES

1. Objectives and decision-making

In view of the many variables involved in the preparation of a plan for water resource management and considering the diversity of situations, it is necessary to classify and arrange these variables, and particularly to propose solutions in a systematic manner (see table 1). A logical sequence of thought usually applied in analysing systems is the following:[5]

a) To define and quantify the objective or objectives and give them a temporal dimension; to indicate the beneficiaries and the relation between principal and secondary objectives and the priority among multisectoral objectives.

b) To identify and analyse the geo-socioeconomic environments and territorial spaces within which it is desired to achieve the previously defined objectives.

c) To determine the problems and quantify the obstacles that must be surmounted in order to achieve the objectives within the geo-socioeconomic environment previously identified.

d) To generate solutions for overcoming the restrictions previously determined, to select and place them in order of priority, and to indicate the method of putting them into practice.

Moreover, when it is not possible to know or adequately to identify and define the objectives, the sphere of action, the restrictions or solutions, research must be carried out in order to obtain the necessary information. The sequence of work is carried out in practice in different ways, reflecting the relative conditions prevailing in each case (see table 2).

González Villarreal has given a clear synthesis of the methodology of the planning of water resource utilization (see table 3). His synthesis emphasizes the interrelation and the flow of measures necessary for formulating a plan of this kind in a particular situation.[6]

The process of decision-making mentioned in the foregoing sequences must necessarily include the time variable. In the plans this variable is designated in different ways, including "horizon", which is a period at the end of which the objective is envisaged. This horizon is usually 25 years. The intermediate periods and intervals up to the limit of the "horizon" are known as "thresholds".

Table 1

LATIN AMERICA: TENTATIVE CLASSIFICATION OF THE VARIABLES INVOLVED IN THE FORMULATION OF PLANS FOR WATER RESOURCES

Spatial coverage							
Politico administrative limits	Hydrographic limits	Sectoral scope	Planning horizons	Agents responsible for planning	Agents in charge of the formulation of the plan	Variables in the application of the plan	Objectives of the plan
International	By water catch-	Multisectoral:	Short-term:	Central	State entities	Instruments of	Economics
	ment and/or	Socio-economic	1 to 4 years	planning agency	Public	plan control:	
Binational	discharge area	Environmental		Sectoral plan-	enterprises		Production
	Basin or system	(control of	Medium-term:	ning agency	Private	Tariffs	Consumption
National	of basins	pollution,	5 to 9 years	Institute	consultant	Taxes	Expansion of
	Valleys	flooding, etc.)		specialized in	companies	Subsidies	cultivated area
Regional	Terraces		Long-term:	water resources	Special	Quotas	Irrigation
	Hillsides	Sectoral	10 to 25 years	Public	executive	Norms/decrees	Energy
Provincial or				enterprises	secretariats		Aquaculture
State		Health	Very long-term:	(mainly energy,	Individuals		Livestock use
		Agriculture	over 25 years	drinking water	Groups of water-		
District		Energy		and sanitation	users		
Municipal		Transport		sectors)	International		
		Industrial		Municipalities	agencies		
Local		Mining		Others			
		Others					

Table 1 (concl.)

Spatial coverage							
Politico administrative limits	Hydrographic limits	Sectoral scope	Planning horizons	Agents responsible for planning	Agents in charge of the formulation of the plan	Variables in the application of the plan	Objectives of the plan
	By water bodies	Subsectoral		Commissions,		Instruments for	Social
	or sources			directorates and		plan application:	Employment
	Surface water:	Irrigation		others			Supply of basic
	Rivers	Fish-breeding				Regionalization	foods
	Lakes	Recreation		Permanent		Legislation	Land
	Lagoons	Others		commissions		Organization	reclamation
	Groundwater					Training	Positive
	Atmospheric			Ad hoc		Public	environmental
	water:			commissions		enlightment	effects
	Fogs					Construction	Regional
	("camanchaca")					Evaluation	integration
	Clouds, etc.					Others	New
	By zones of						opportunities
	conflict						Control of
	Flood zones						environmental
	Drought zones						conflicts
	Erosion zones,						
	etc.						

Table 2

SEQUENCE FOR IDENTIFYING THE OBJECTIVES OF A PLAN FOR WATER RESOURCE MANAGEMENT, THE MEDIUM IN WHICH TO ACHIEVE THESE OBJECTIVES, THE PROBLEMS THAT MUST BE OVERCOME FOR THIS PURPOSE AND THE ALTERNATIVE SOLUTIONS

A. OBJECTIVE

To have a constant supply of water adequate in quantity, quality, place and time to meet the needs of consumption, production and environment and to have protection against adverse effects associated with water resource management.

B. GEO-SOCIOECONOMIC MEDIUM

Hydrographic basin(s) or region(s) delimiting the sphere in which it is planned to harmonize water supply and demand to meet the objective(s) indicated above.

C. CONSTRAINTS

Physical and natural: To augment the water supply, increse efficiency in use or minize natural conflicts and in general satisfy water requirements and water conservation conditions.

Socioeconomic: a) political and legal, to permit and execute plans in accordance with the interests of society; b) economic and financial, to allocate the economic and other resources needed to carry out the necessary technical measures; c) social and cultural, to implement with due knowledge and preparation of the measures required to achieve the planned objectives, and d) institutional and administrative, to organize and implement the measures in an effective manner.

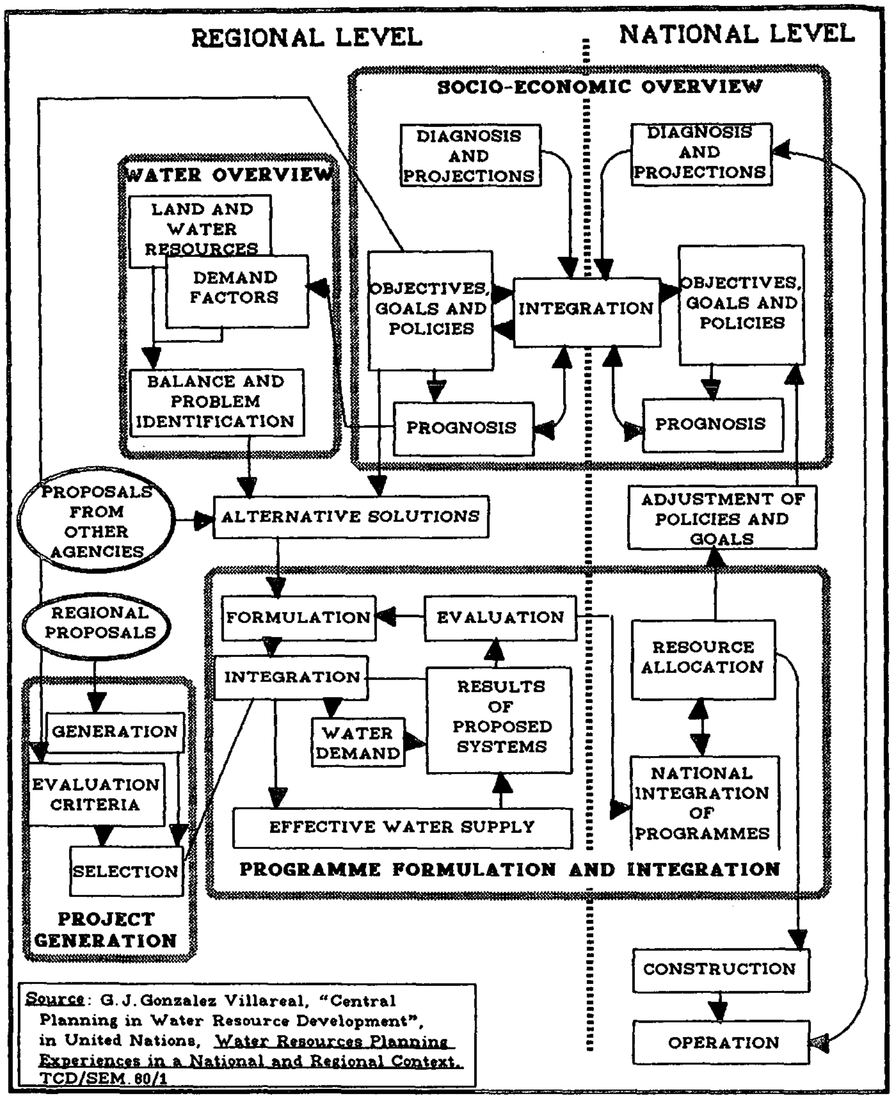
D. SOLUTIONS

Technical or engineering solutions: To overcome physical or natural problems. Includes activities such as studies of resources, formulation of projects, constructions of hydraulic works, operation and maintenance of hydraulic systems, and management and conservation of basins, water and other natural resources.

Political or administrative solutions: To permit the orderly execution of the technical or engineering solutions. Includes such measures as legislation, planning, financing, training, research, institutionalization, control, fiscal supervision, rationalization, personnel administration, information, etc.

Source: Axel Dourojeanni, **La planificación para el desarrollo, aprovechamiento y manejo de los recursos hídricos**, Course on the environmental dimension in development planning, CIFCA/ILPES/ECLAC/UNEP, Santiago, Chile, 20 October to 28 November 1980, document CDA-24.

Table 3:
THE METHODOLOGY OF THE PLANNING PROCESS



Source: G. J. Gonzalez Villareal, "Central Planning in Water Resource Development", in United Nations, Water Resources Planning Experiences in a National and Regional Context, TCD/SEM.80/1

2. Water regionalization as a basis for harmonization of water supply and demand

A regionalization of water is the first step in the structuring of an adequate framework for using and managing water in a country (see figure 4). This framework serves a double purpose: it makes it possible to find units of study for the harmonization of water supply and demand and also to fix the limits for the operation and management of water systems.[7] Within each zone, the initial step is the projection of water demand. Theoretically there should be a national economic development plan and, in addition, sectoral and regional plans as components of the former, which should make it possible to foresee the sectoral demand in each zone or basin. In the absence of such plans, considerable labour will be called for in preparing a description of the socioeconomic characteristics and trends in each zone. There are different methodologies for carrying out this task which have been fully analysed in the reference document,[8] and also in the methodological bases of the Plans of Venezuela, Mexico and Peru, among others.

In the analysis of the supply of surface and groundwater, it is considered that the most important physical features are the following: precipitation, generated and available run-off, soils, discharges into rivers, hydrology and volume and overloading of aquifers. The preparation of studies on water supply and demand and the balances confer numerous immediate benefits on the country carrying out this work. With this system zones are detected which have water incompatibilities of different kinds: in terms of quantity, quality, place and time and for several thresholds of planning, along with the reasons for the occurrence or possible occurrence of these incompatibilities. In principle, it helps to compile and rationalize quantitative information, usually dispersed, in a data bank, and to co-ordinate activities among agencies which are not accustomed to exchanging information despite their need for it. Equally, it facilitates the finding and priorizing on a global level of a series of actual and potential conflictive situations in the short, medium- or long-term (see table 4).

The problems in harmonizing water supply and demand may be divided into two groups: natural or physical problems and politico-administrative problems. In the same way, the solutions may be divided into those of a technical or engineering type, when these are aimed at solving problems of a physical nature, and solutions of a directive type, when they are designed to overcome problems of a politico-administrative nature.

Figure 4

MAP OF MEXICO SHOWING THE WATER-PLANNED REGIONS

Source: Comisión del Plan Nacional Hidráulico, "Plan Nacional Hidráulico 1981", México, D.F., March 1981.

Note: The boundaries and names shown on this map do not imply official endorsement or acceptance by the United Nations.

Table 4

CONFLICTIVE SITUATIONS IN A DIAGNOSIS OF WATER RESOURCE SUPPLY AND DEMAND

Situations	Considerations and/or ranges established for classification
1. Main zones of overexploitation of aquifers and resultant effects	1. Lowering of levels 2. Saline intrusion of water migration 3. Land subsidence of fissures
2. Zones of prohibition of groundwater use	1. According to agencies responsible for its control
3. Annual losses by overflow	1. Very high (over 1 000 Mexican pesos per km2) 2. High (from 50 to 999 Mexican pesos per km2) 3. Medium (from 200 to 499 Mexican pesos per km2) 4. Low (under 200 Mexican pesos per km2)
4. Dams which need a review of their surplus water constructions	1. Indication of capacities
5. Incidence of drought in the last 100 years	1. High (over 12 droughts) 2. Medium (from 7 to 12 droughts) 3. Low (under 7 droughts)
6. Water pollution at basin level	1. Heavily polluted 2. Polluted 3. Good quality
7. Pollution of surface and groundwater at locality level	1. Deficit of dissolved oxygen 2. Nutrients 3. Fats and oils 4. Coliform elements 5. Toxic elements 6. Intrusion

Table 4 (concl.)

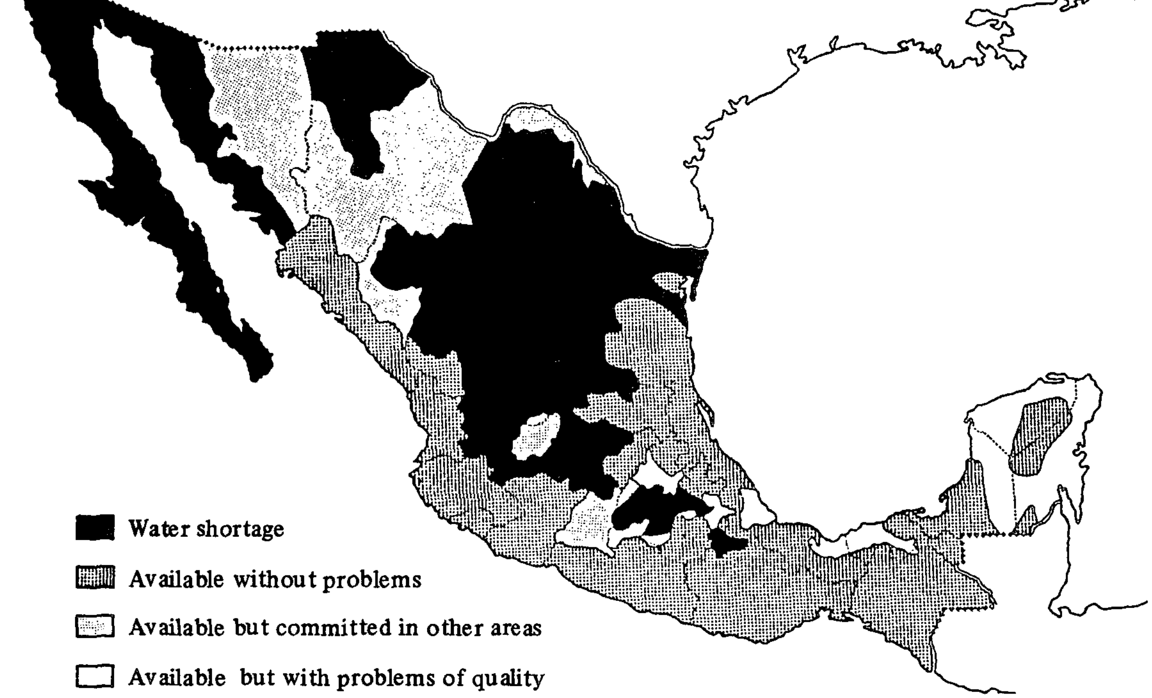
Situations	Considerations and/or ranges established for classification
8. Sediment concentration in rivers and risks of water erosion	1. Over 0.4% of the run-off
	2. From 0.1% to 0.4% of the run-off
	3. Under 0.1% of the run-off
	4. High risk of erosion
9. Identification of conflicts of water supply to localities	1. With actual and future conflict
	2. With future conflict
	3. With actual conflict but with alternative non-conflictive sources of supply
	4. Without studies of groundwater but with evidence that it exists
	5. Without conflicts up to the year 2000
	6. With present conflicts respecting water quality
10. Water balances by basins, zones and/or regions	1. Rain
	2. Natural availability (millions of m3)
	3. Supply with infrastructure (millions of m3)
	4. Demand
	5. Extraction (millions of m3)
	6. Balance I
	7. Natural availability (millions of m3)
	8. Balance II
	9. Total consumption
	10. Consumption and extraction within natural availability

Source: Plan Nacional Hidráulico de México, México, D.F., 1981.

Finally, the water balance makes known the national, regional and local availability of water (see figure 5 and table 5); the zones of water shortage, the zones where there is no problem of supply, the zones where the supply is committed in other areas, and the zones with a supply which has quality problems for different thresholds and horizons of time. The balance represents a basic contribution to the development of the policies of utilization and management in the short, medium- and long-term.

Figure 5

MEXICO: REGIONAL AVAILABILITY OF WATER



Source: Comisión del Plan Nacional Hidráulico, "Plan Nacional Hidráulico 1981", México, D.F., March 1981.

Note: The boundaries and names shown on this map do not imply official endorsement or acceptance by the United Nations.

Table 5

WATER BALANCE OF MEXICO 1981

Zone	Rain		Natural availability			Year	Of. Com. Infrastructure			Demand	Extraction		
	Stratum mm	Volume	Virgin run-off	Aquifer recharge	Total		Surface	Under-ground	Total		Surface	Under-ground	Total
		Millions of cubic metres											
North	425	242 406	11 669	4 528	16 197	1980	11 169	3 383	14 552	14 232	10 959	3 383	14 342
						1990	14 596	4 656	19 252	19 355	14 108	4 656	18 764
						2000	16 493	5 168	21 661	21 797	15 805	5 168	20 973
Pacific	568	294 546	49 356	4 548	53 904	1980	25 120	5 244	30 364	30 413	23 266	5 244	28 510
North and						1990	45 790	5 718	51 528	50 813	43 757	4 758	48 515
Centre						2000	70 360	6 117	76 477	75 481	68 332	5 073	73 405
Centre	946	265 531	55 475	7 750	63 225	1980	52 010	5 692	57 702	57 565	51 873	5 692	57 565
						1990	71 209	6 545	77 754	77 210	70 928	6 282	77 210
						2000	95 366	7 564	102 930	102 778	95 123	7 322	102 445
Gulf and	1 716	787 304	277 942	14 218	292 160	1980	72 673	1 308	73 981	53 557	52 249	1 3087	53 557
Southeast						1990	129 639	2 302	131 941	99 743	97 441	2 302	99 743
						2000	304 063	3 677	307 740	281 134	277 590	3 877	281 467
Mexican	864	1 589 787	394 442	31 044	425 486	1980	160 972	15 627	176 599	155 767	138 347	15 627	153 974
Republic						1990	261 234	19 241	280 475	247 121	226 234	17 998	244 232
						2000	486 282	22 526	508 808	481 190	456 850	21 440	478 290

Table 5 (concl.)

Zone	Balance I	Additional availability: Re-use	Additional availability: Import (+) Export (-)	Additional availability: Total	Balance II	Total consumption	Extraction/consumption Natural availability		Natural availability Inhabitants (m3/inhab/year)
	Millions of cubic metres								
North	110	440	-454	-14	96	9 996	0.89	0.62	1 609
	- 591	949	-358	591	0	11 608	1.16	0.72	1 288
	-824	1 182	-358	824	0	13 032	1.29	0.80	1 044
Pacific	- 1 903	4	1 850	1 854	-49	17 677	0.53	0.33	6 595
North and	-2 298	88	2 210	2 298	0	23 937	0.90	0.44	5 030
Centre	-2 076	221	1 855	2 076	0	30 107	1.36	0.56	3 905
	0	0	0	0	0	14 690	0.91	0.23	1 885
Centre	0	0	0	0	0	21 158	1.22	0.33	1 488
	-333	0	333	333	0	24 559	1.62	0.39	1 206
Gulf and	0	0	0	0	0	6 614	0.18	0.02	18 717
Southeast	0	0	0	0	0	17 175	0.34	0.06	15 359
	333	0	-333	-333	0	36 305	0.96	0.12	12 898
Mexican	-1 973	444	1 396	1 840	47	48 977	0.36	0.12	6 131
Republic	-2 889	1 037	1 852	2 889	0	73 878	0.57	0.17	5 018
	-2 900	1 403	1 497	2 900	0	104 003	1.12	0.24	4 076

Source: Plan Nacional Hidráulico de México, México, D.F., 1981.

Another aspect worthy of emphasis in the attempt to detect problems of harmonization of water supply and demand is that these problems are both technical or physical and administrative or political in origin. The study of the problems of harmonizing water supply and demand should consider both groups of problems and not be limited to the technical or physical aspects if the aim is to provide better elements of judgement for the formulation of utilization strategies. This is particularly important as a basis for designing the solution strategies. Outstanding in this group of problems are those created by society itself and its organization, such as inefficiency in the use of available water, the disproportionate growth of demand in zones with a water shortage, the lack of ineffectiveness of current legislation, the lack of interinstitutional co-ordination, the scant or non-existent public participation, the unequal budgetary allocations, the lack of specialized personnel, etc.

From the technical or engineering standpoint, the solutions for harmonizing water supply and demand are of two types: those which seek to obtain and deliver new sources of water that meet the requirements of quantity, quality, place and time, and those which aim at the more efficient utilization of the water already obtained or the limitation of its use.

In the first case action is taken on the supply, converting the potential water supply into reality. Usually this is achieved through the construction of water works for the retention, storage, regulation, control, channelling, management, treatment, distribution, recycling and/or disposal of the water. This group also includes the techniques for managing the natural sources of water retention: catchment basins, groundwater, areas of mist, management of snow, desalinization and artificial rain.

In the second case, the main objective is to reduce demand by means of: i) greater efficiency in the use of available water, by improving the performance and maintenance of the systems already constructed and developing techniques for a lower consumption per unit of use, along with the prevention of contamination, and ii) a control of the growth of demand in zones of water shortage. In both cases the participation of the user is essential, so that options for the training of users should also be included.

In order to carry out any of the possible alternatives for increasing supply or reducing demand, technical strategies must be combined with those of management. This latter group includes aspects relating to administrative organization, financing, training, the organization of users and, in fact, everything that will facilitate the execution of measures for the utilization, management, control, preservation and conservation of water.

Obviously the harmonization of water supply and demand must also take into account multisectoral uses of the resource, actual and potential, and not only the sectoral. Although this is obvious from a theoretical standpoint, it is usually ignored in practice, particularly owing to the sectoral origin of water projects. It is only taken into account when conflicts arise regarding its utilization and then "emergency" measures have to be taken.

To sum up, in putting forward solutions for harmonization, it is necessary:

a) To provide, in a proportionate and co-ordinated form, alternative solutions both for increasing water supply and for reducing demand.

b) To provide, in a proportionate and co-ordinated manner, solution strategies not only of a technical and engineering type but also those of management or direction.

c) To provide alternative solutions which will be co-ordinated with all the sectors using water, actual and potential, within the territorial area of the planning.

d) To generate options in accordance with the available resources so that they can be put into practice and be politically feasible, in order that they may be effectively taken into account as elements of decision for social and economic development and environmental management.

3. The relation between the national planning of water resources, the planning of basins and the formulation of projects

The planning of water resources is carried out at successive levels of detail. The data that appear in figures 4, 5 and 6 constitute the basis for strategic decisions on the place within the national water system in which policy intervention should be contemplated. The next level assumes practical decisions as to the manner of intervention in the equation of supply and demand, which entails a more detailed approach within the context of zones or river basins, leading to the identification and formulation of alternative projects. This is usually known as the incorporation of the environmental dimension, which is in effect a process of planning and policies and the formulation of projects adjusted to a broad definition of the system of physical resources which are to be administered along with the potential interactions between this system and the socioeconomic institutional system within a relatively long temporal horizon.

Figure 6

SEQUENCE OF TECHNICAL ACTIVITIES NEEDED FOR THE DEVELOPMENT AND MANAGEMENT OF A BASIN OR AN AREA WITHIN A BASIN

Order of activity	Generic name of activity	Measures included in each activity				Result[a]
Preliminary activities	Assessment of the basin (first stage)	Inventories	Studies (semi-detailed and/ or detailed reconnaissance)	Assessment of the resources	Diagnosis for their utilization and conservation	Knowledge of present and potential situation
	Formulation of projects (second stage)	Determination of objectives and goals	Execution of specific studies	Designs and plans for execution	Economic and financial analysis and preliminary budget	Planning of the future situation
Intermediate activities	Execution of projects (third stage)	Construction of camps and auxiliary works	Construction of major and minor infra-structure	Equipment of project	Incorporation and starting up of system constructed	Execution of the projects in the time proposed

Figure 6 (concl.)

Permanent activities	Operation and maintenance of structures (fourth stage)	Organization of State and/ or enterprise users	Operation of the structural and auxiliary systems	Periodic maintenance of the structures and equipment in operation	Repair of auxiliary structures and equipment	Permanent efficient use of the physical investment
	Management and conservation of natural resources (fifth stage)	Regulation of the basin use according to its capacity	Management of water soil, crops, pastures and woods, fauna, mining, energy, and other resources	Protection of resources against negative effects	Recovery and rehabilitation of zones affected by bad use or natural phenomena	Permanent quality, quantity and frequency of supply of resources of basin or area administrated

Source: CIFCA/ILPES/ECLAC, ***La planificación para el desarrollo, aprovechamiento y manejo de los recursos hídricos,*** document No. CDA-24, presented to the Course on the Environmental Dimension in Development Planning, held in Santiago, Chile, between 20 October and 28 November 1980.

[a]The overall effect of all the results is the uninterrupted supply of water and production (agricultural, enery-related, etc.) over time.

The most prominent features of the processes of water resource planning within the framework of the integral management of resources are: i) the possibilities of generating alternative uses and preventing undesirable effects; ii) its inevitably unpredictable or uncertain character, particularly in the long-term, and hence the need that it should be dynamic and interactive in order to be able to incorporate new data with the passage of time; iii) the need that it should be formulated by interdisciplinary teams in order to have the required depth and power of integration, and iv) the need that in the formulation and execution of the plans a given geographical area should be covered in a given lapse of time. All these characteristics are mutually complementary, so that the incorporation of the environmental dimension in the planning of water resources should be initiated from the moment when a development aim is put forward which requires the harmonization of water supply and demand.

As regards the first point, it must be stressed that the act of "incorporating the environmental dimension" is an exercise which makes it possible to generate a larger number of options for the utilization of the resources in taking possible chain effects into account, and also to avoid or prepare to control or attenuate undesirable consequential effects. This aspect is emphasized because it is usual to assume that the purpose of "incorporating the environmental dimension" is solely to "control the negative effects" and therefore it is usually associated exclusively with costs, without considering that it may potentially generate an equal or greater number of benefits.

In the second place, it should be borne in mind that planning by definition deals with activities for the future and hence is based on predictions with very differing degrees of certainty. Planning for water resource management is no exception to this unavoidable risk, particularly if the aim is not only to programme the execution of initial measures —such as to decide whether or not to build a dam— but also to undertake this exercise with a prior knowledge of the possible chains or networks of effects which will materialize in the future as a result of this decision. The exercise is, in consequence, largely an "art of planning the unknown" within very variable ranges of uncertainty, ranges which will only be reduced in so far as an increasingly precise knowledge is acquired of the possible chains or networks of effects of each intermediate action in the short, medium- and long-term.

The material impossibility of predicting all the probable consequences of a measure which changes the environment makes it necessary, moreover, to maintain a permanent watch or supervision over the places affected in order to take new measures to deal with unexpected changes. This calls for an administrative system with sufficient capacity and flexibility to react to unexpected situations discovered during the supervision if it is desired that this exercise should be useful.

The best way to formulate plans for the management of natural resources —minimizing ranges of uncertainty— is to work with professional groups of different disciplines and obtain the direct participation of the potential beneficiaries of the plans.[9]

In the final analysis, water resource planning must concern itself with the implementation of policies which involve "software", e.g. pricing and tax, and "hardware", e.g. water regulation and distribution structures. In the development of water resource utilization there are three clear and differentiated stages (see figure 6). In the first stage, studies are made and projects formulated; in the second or intermediate stage, the projects is constructed or executed, and in the third stage, permanent or periodic, the water works constructed are put into operation and maintained and the water resources are managed and conserved.

Respecting basin planning, it should be noted that the biophysical features of a river basin form relatively coherent hydroecological system which make them the basic unit for water resource management. For planning to be effective the management plan must be integrated, that is, it must include the co-ordinated and harmonious treatment of all the forms of water use, management and control, such as irrigation, drainage, the production of hydro-electricity, navigation, flood control, erosion control, the management of the flora and fauna of the basin, the domestic and industrial use of water, recreation and the conservation of the environment. It is also essential that it should form part of regional or national development plans.[10] Nevertheless, if the basins are very large, as in the case of the River Amazon or the River Plate, which encompass different political, socioeconomic and cultural frontiers, these areas are inappropriate as units of planning.[11]

The units of planning are the same as those described in point B.

B. A COMPARATIVE ANALYSIS OF NATIONAL WATER RESOURCE MANAGEMENT PLANS

This chapter is based on a series of technical studies conducted in Argentina, Bolivia, Cuba, Colombia, Ecuador, El Salvador, Honduras, Trinidad and Tobago, Haiti, the Dominican Republic, Peru, Paraguay, Mexico and Venezuela, as well as information published on the other countries (see table 6). The planning of multisectoral water use at the national level is carried out with varying degrees of advancement in almost all the countries, although an appreciable number have placed greater emphasis on plans of a sectoral national type, mainly concerned with energy or irrigation or integral plans in some selected river basins.

The countries studied which have the more advanced multisectoral national plans are Mexico,[12] Venezuela,[13] Peru,[14] and El Salvador,[15] of which Mexico, El Salvador and Venezuela have published plans. Next come Ecuador,[16] Colombia,[17] Honduras,[18] Jamaica,[19] and the Dominican Republic,[20] the first has already prepared the basic documents for the realization of long-term plans and Honduras has a plan for the medium-term.

The purpose of this preliminary comparative assessment of these plans is to identify possible spheres of mutual co-operation among national bodies with a view to improving the planning process and highlighting the chain of decisions involved in the development and management of water resources. Some of the factors regarded as of special importance in the attempt to establish some comparisons between the different national plans for the management of available water resources are the following:

a) The aims and goals set forth in the plans for water resource utilization and the way in which they are related to objectives of national or regional development.

b) The relative degree of experience and progress in the formulation and application of plans at national level.

c) The organization and method used for the formulation of national plans.

d) The structure and content of the national plans.

1. Aims and goals of the plans

The situation regarding the formulation of water management plans by countries of the region is given in table 6. In an initial examination of this table it will be observed that the titles of the plans in Spanish differ appreciably in several terms, which does not necessarily indicate changes in the objectives or in the scope of the plans but certainly implies problems of form. Respecting the aims of the plans indicated in the titles, it will be seen that some employ the terms "desarrollo", "ordenamiento" and "aprovechamiento", while others use none of these terms. Moreover, the terms "aguas", "hidráulico", "recursos hidráulicos" and "recursos hídricos" are used as equivalent terms in practice. It is evidently a question of

Table 6

PLANS FOR WATER RESOURCE MANAGEMENT IN LATIN AMERICA AND THE CARIBBEAN

Country	Name of plan at national level	Starting year	Publication year version 1	Publication year version 2	Co-ordinating body	Executing bodies	International advice/ assistance	Observations
Argentina	No plan	Tentative 1986	-	-	-	-	-	-
Bahamas	No information	-	-	-	-	-	-	-
Barbados	No information	-	-	-	-	-	-	-
Bolivia	No plan	-	-	-	-	-	-	-
Brazil	No plan	-	-	-	-	-	-	-
Colombia	Plan Nacional de Aguas	1982	-	-	Departamento Nacional de Planeación	National Consultants	ECLAC	-
Costa Rica	No plan	-	-	-	-	-	-	-
Cuba	Plan de Aprovechamiento Hidráulico	1970	n/i	n/i	-	Instituto de Hidroeconomía	n/i	-
Chile	No plan	-	-	-	-	-	-	-
Ecuador	Plan Nacional Hidráulico	1982	-	-	Instituto Nac. Recursos Hidráulicos (INERHI)	INERHI	OAS/ Government of Spain	-

Table 6 (cont. 1)

Country	Name of plan at national level	Starting year	Publication year version 1	Publication year version 2	Co-ordinating body	Executing bodies	International advice/ assistance	Observations
El Salvador	Plan Maestro de Desarrollo y Aprovechamiento de los Recursos Hídricos	1979	1983	-	Ministry of Agriculture	Ministry of Agriculture	UNDP/TAHAL	-
Guatemala	No plan	-	-	-	-	-	-	-
Guyana	No information	-	-	-	-	-	-	-
Haiti	No plan	-	-	-	-	-	-	-
Honduras	Plan Nacional de Recursos Hídricos	1979	1979	-	Consejo Superior de Planificación Económica (CONSUPLANE)	CONSUPLANE	-	Only short-term plan (1979-1983)
Jamaica	National Water Resources Development Master Plan	1984	-	-	Water Resources Division	Water Resources Division	UNDP/Government of Israel	Project document
Mexico	Plan Nacional Hidráulico	1972	1975	1981	Comisión del Plan Nacional Hidráulico	Comisión del Plan Nacional Hidráulico	UNDP in first phase	

Table 6 (concl.)

Country	Name of plan at national level	Starting year	Publication year version 1	Publication year version 2	Co-ordinating body	Executing bodies	International advice/ assistance	Observations
Nicaragua	No information	-	-	-	-	-	-	-
Panama	No plan	-	-	-	-	-	-	-
Paraguay	No plan	-	-	-	-	-	-	-
Peru	Plan Nacional de Ordenamiento de Recursos Hídricos	1977	-	-	Comisión Multisectorial del Plan Nacional de Ordenamiento de los Recursos Hidráulicos	Various State entities	Government of Venezuela and OAS	
Dominican Republic	No plan	-	-	-	-	-	-	-
Suriname	No plan	-	-	-	-	-	-	-
Trinidad and Tobago	No plan	-	-	-	-	-	-	-
Uruguay	No plan	-	-	-	-	-	-	-
Venezuela	Plan Nacional de Aprovechamiento de Recursos Hídricos	1968	1972	-	Comisión del Plan Nacional de Aprovechamiento de los Recursos Hidráulicos	Working group of State entities		

n/i = No information.

language rather than meaning.[21] It would seem that the most appropriate and least restricted of the phraseologies commonly employed, especially if one takes into account the desired scope of the plans, is the title "Plan Nacional de Ordenamiento de Recursos Hídricos" or "de Aguas".

In the objectives of the plans analysed two types of orientation can be discerned which are not always identifiable or separable.

a) The plans whose objectives are clearly linked with socio-economic development strategies at national, regional or basin level are of an integral and long-term character.

b) The plans whose objectives are mainly concerned with water resources of a sectoral or subsectoral nature are mainly directed to the priority ranking of projects for water resource utilization but they do not clearly establish their link with global development plans and are for the medium-term.

The definition of the plans and their objectives reflects to some extent the scope attributed to them in each country. The apparently more integral definitions and objectives include the following:

"To establish a rational, equitable and effective utilization of water, in terms of the requirements of the different uses: social (urban, tourist, recreational, etc.), economic (agricultural, industrial, mining, etc.), and natural (flora and fauna) in the country, in accordance with priorities, overcoming the factors which restrict its availability (scarcity, excess, poor quality, etc.) and ensuring ecological equilibrium; all of which calls for a profound knowledge of its spatial and temporal availability".[22]

"The national plan for the utilization of water resources is a frame of reference made up of a set of strategies and directives which, within the general policy of development and an adequate legal and institutional management, ensures the rational administration of the resource and therefore establishes a logical and reasonable distribution between the supplies of water and the probable demands ... the plan is conceived as a process which seeks to define and specify the decisions concerning the resource in order to maintain a quantitative and qualitative balance between demand and availability, so as to prevent the conversion of water into a limiting factor in the economic and social development of the country ...". The objective of the said plan is summarized as "... the maintenance of a dynamic balance between supplies and the different demands which may need to be met in the development of the country.[23]

Other definitions and objectives point in general to the same aspects, such as:

"The general objective of the national water plan is to enable the country to complete or develop the instruments for a coherent, technical and forward-looking planning of the water resource in order to a) meet future demands in respect of supply and quality of water for human consumption, b) ensure the flows and qualities needed for the generation of hydro-electricity, navigation, aquaculture, irrigation, recreation and the sustained improvement of ecosystemic productivity, c) ensure defence against the destructive action of water and protect water and soil from human action when this is detrimental to these resources".[24]

The following are also indicated as immediate objectives of a plan: "to increase the knowledge of the country's water resources and their potential, to promote the rational utilization of these resources in order to ensure the water balance, to strengthen institutional aspects and co-ordination in respect of water administration and to train personnel".[25]

Some plans indicate as objectives a set of measures designed to achieve water management integrated with land and forestry resources, to promote a better utilization and preservation of water in each of the user sectors, improve water management, improve the participation of the different sectors of the population in the efficient use of the resource, and intensify research and training in order to deal with aspects of the operation and maintenance of hydraulic works and the handling and conservation of the resources through an adequate organization and training of the users and those who are responsible for assisting them.[26]

In sum, the intentions set forth in the different plans analysed can be listed as follows:

a) To maintain a dynamic equilibrium between supplies and the different demands for water implicit in the development of the country (water policy).

b) To conserve the ecological balance; to preserve, protect, conserve, and manage the resources efficiently; to make rational use of water, etc. (environmental aspects).

c) To ensure defence against the destructive action of water, to be protected against damaging effects, to control the discharge of water (an aspect relating to the control of natural problems or catastrophes).

d) To improve the management of water and basins; to achieve water management integrated with the resource of land and forests; to organize the users, train them, improve interinstitutional relations in respect of water administration with clear reference to the operation and maintenance of hydraulic works and the management and conservation of water and related resources (efficiency in the use of water and water systems).

e) To increase knowledge of the availability of water resources in the country and of their potential, to undertake research and other aspects associated with the systematic assessment of the water supply.

f) To determine priorities of investment in projects and activities to harmonize water supply and demand. In general, to give priority mainly to investment projects aimed at increasing the water supply.

Generally speaking, all the plans mention directly or indirectly the first point indicated above. The other aspects are not common to all the plans. For example, only three are categoric in emphasizing the need to improve and stimulate the operational phase of the water systems in order to achieve good water management with user participation.

2. The relative degree of experience in the formulation of plans

In all the countries of Latin America and the Caribbean there is some degree of experience in planning for the management of water or water resources, especially at the sectoral levels of health, agriculture and hydroenergy, on the basis of river basins. This has apparently enabled many governments of the region to execute or initiate the formulation of plans for the management of water resources both multisectoral in character and of national coverage.

Mexico is the country that has gone furthest in this activity, which must be attributed to the special needs of a country with extensive arid zones.[27] Cuba also has a plan which was initiated in 1970.[28] Then there are Venezuela, Peru and El Salvador to be considered. This last country has published the final reports of its planning initiated in 1979. With regard to other countries, the majority have in fact embarked upon the formulation of their plans in a more recent period which includes the last five years; these include Colombia, Ecuador and Honduras, and there are several more which have at least preliminary studies at their command, such as Jamaica[29] and the Dominican Republic.

At present Argentina and Brazil have no multisectoral plans at the national level. Both countries, however, have wide experience on the subject, especially as regards large river basins and at sectoral levels, particularly in respect of drinking water, energy and (more recently) irrigation problems. Chile has not programmed the formulation of a multisectoral national plan but is known to possess considerable information and experience in sectoral and basin planning. Similarly, but on different grounds, Uruguay has indicated that its long-term water requirements had already been covered, especially in the energy field, and that its present supply of water made it unnecessary to formulate a plan of this kind.

In Bolivia and Paraguay the user sectors are interested in having a national water plan, but various factors have so far prevented a start being made on its formulation and execution. In Panama, Costa Rica, Guatemala and Nicaragua there are proposals for formulating a long-term plan but for diverse reasons they have not yet materialized.

3. The organization and methods used for the formulation of plans

The plans have usually been initiated in some institution associated with the water sector of the central planning sector. In Peru, for example, it began in the General Water Department (Dirección General de Aguas) of the agricultural sector and was then transferred to the National Planning Institute. In Mexico it was concentrated in the Secretariat for Water Resources. In Ecuador it is prepared through the Ecuadorian Institute for Water Resources (Instituto Ecuatoriano de Recursos Hidráulicos - INERHI). In El Salvador it was initiated in the agricultural and livestock sector and in 1981 a specialized office for water resources was set up in the Ministry of Planning.

Once the initiative has been taken multisectoral commissions are usually set up with one or another of the agency heads as chairman. These commissions are constituted at two levels: at a decision-making level, integrated by representatives of various sectors, and at a technical level, formed in many cases by personnel who have been specially hired for certain tasks. Examples of this are the commissions of Venezuela, Peru and Mexico. The direction of these commissions is distributed in the region among:

a) National planning institutes or their equivalents (Peru, Colombia, Honduras and El Salvador).

b) Secretariats, ministries or institutes for natural resources or the environment (Venezuela).

c) Secretariats or ministries of agriculture or energy or other sectors closely concerned with the field of water (in several countries the agricultural sector is responsible for natural resources).

d) Secretariats or national institutes for water resources or their equivalents (as in the case of Cuba, Ecuador and Mexico, although in this last case the Secretariat of Water Resources was subsequently associated with the Ministry of Agriculture).

The method of carrying out the plan differs from country to country in the region. In some cases the work is entirely carried out by State or semi-State agencies through a distribution of tasks. This is the case, for example, in Ecuador, Peru and Mexico, among others. In other cases the work is conducted partly by the State and partly by one or more consultant firms, as in El Salvador. Lastly, in Colombia the work was assigned almost exclusively to a consultant firm, with the support of the national institutions. In other cases working groups are organized according to tasks as in the case of the Dominican Republic.

Plans have usually been carried out in successive stages or phases, as in Ecuador, El Salvador and Colombia.

In practice the formulation of all the plans analysed has received some form of external assistance. Peru received assistance from the OAS, the Government of Venezuela, ECLAC and ILPES (for its prospective model). Ecuador received assistance from the Government of Spain, UNDP and ECLAC, Colombia from ECLAC, while the Dominican Republic was supported by the IICA through the mediation of the Consultant Warren Hall of Colorado State University. El Salvador received assistance from the UNDP and the consultant firm of TAHAL, while Mexico was aided by the UNDP and the World Bank and Jamaica by the UNDP.

4. The structure and content of the plans

The comparative analysis of the management plans available reveals a general structure incorporating the elements considered in section A. To begin with there is the development of a logical sequence in the definition of objectives, the geographical area involved, and the restrictions and options in respect of action. For example, the "Master Plan for the Development and Utilization of Water Resources in El Salvador" mentions as inevitable tasks in the development of the plan the study of the available resources, the analysis of foreseeable needs, the study of solutions to meet these needs on the basis of the aforesaid resources and, in relation to all the foregoing, the adaptation of the legal and institutional infrastructure to permit the implantation and operation of these solutions in the long term. The "National Plan for Water Resource Management" of Peru[30] is more explicit in setting out the following tasks for the execution of the project: a) the preparation of a prospective model which takes the form of a classification of the objectives of the plan through the projection of a future scenario desirable within the economic and social structure as a whole and determined by the policy lines put forward for the country in accordance with the prospects of achieving them; b) the regionalization of water, which comes to be the clarification and delimitation of geo-socioeconomic spheres, generally a basin or a group of river basins; c) the determination of demand by water-related regions and water-using sectors; d) the determination of the potential (supply) of water as a resource; e) the balance between demand and availability; f) specific studies mainly concerned with environment and protection, and g) the formulation of strategies and definition of a national water policy establishing principles and norms and proposing programmes for the utilization, conservation, protection and improvement of water resources.

Absolutely all the countries that have formulated national plans for water resource management, both multisectoral and sectoral, have subdivided the country into regions which have usually been described as hydraulic or hydrographic. In every case, moreover, river basins have been regarded as a starting point for this regionalization and then an attempt has been made to harmonize their natural or physical boundaries with those of a politico-administrative type.

The Peruvian plan has taken as its spatial sphere for water planning the river basins, designated "hydrographic analysis units". The interconnected water systems of one or more basins constitute the "operational areas" and one or more "operational areas" constitute a "hydraulic" (i.e., water-related) region.

Following a similar criterion and also taking the hydrological basin as a basic planning unit, Mexico's water plan divided the country into 14 regions (see figure 4), each of comprises the basin of a large river or several homogenous basins of secondary importance. The regions were divided in their turn into 104 subregions with a view to seeking similar areas from a socio-economic standpoint, which might be regarded as minimum modules of analysis. In the division into subregions political and municipal boundaries were taken into account. The regions were also grouped into four zones: Pacific North and Centre, North, Centre, and Gulf and Southeast. To carry out the aforesaid regionalization —as explained in the Venezuelan plan, which was one of the first to be implemented— several criteria were used, the main one being the hydrographic basin and the operation of water systems, but also including environmental, demographic, economic, social and political criteria.

The progress made in the formulation of plans by a number of countries has already enabled them to place more emphasis on the development of policies and strategies. This can be seen in the Mexican report which, in comparison with other plans whose execution is not so far advanced, recommends concretes measures both in the field of general water management and in respect of specific projects, as part of the strategies derived from the diagnosis. By way of example, figures 7 and 8 give the conceptual schemes developed respectively by Peru and Ecuador. These, as can be seen, reflect a similar structure with different degrees of detail.

The theory underlines the importance of establishing ample time horizons and achieving an institutional co-ordination in the execution of plans, as well as achieving a relationship between plans, resource allocation and water management. In practice it has been found that the best strategy is for the national water management plans to include short-term goals among their objectives and not to limit themselves to medium- and long-term planning. This encourages the governments, which normally have a term of five years, to take more interest in supporting their execution. Generally speaking few plans regard it as beneficial to assess and quantify institutional problems in due depth; their authors frequently confine themselves to the study of physical aspects, which subsequently reduces the possibility of carrying out the plans.

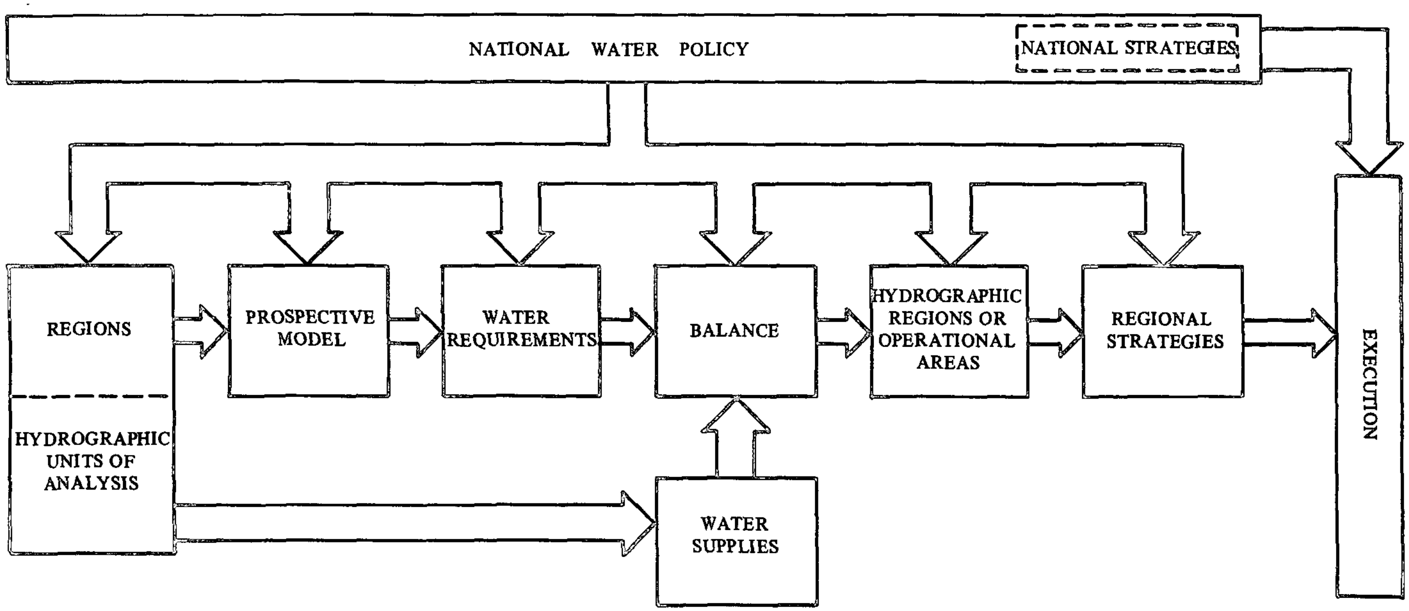
With regard to the linkages of the plans with financial and technical resource allocation and possibly with the management of water and related resources, the plans are generally centered on capital investment policies, at the expense of operational and maintenance policies, etc., which may change the patterns or improve the effectiveness of water use.

To illustrate this point, in a study made in Peru,[31] already outlined in section A, it was pointed out, for example, that in 1979 that country allocated 82% of its total investments in the agriculture and food sector exclusively to the development, use and conservation of water ad soil. Nevertheless, out of this proportion, which indicates the very high priority given by the Peruvian government to this subsector, the State assigned only 0.8% to the assistance of users in the operation and maintenance of the hydraulic systems already constructed and only half this to the management and conservation of water and soil resources (see figure 9). The exception under the latter head is the attention at present devoted to the drainage and reclamation of land on the coast, 30% of which has been affected by progressive salinization as a result of the prevailing natural conditions and irrigation.[32]

The distortion in investments is repeated in different degrees in other Latin American countries and in other water-using sectors, especially in the case of drinking water and sanitation, all of which

Figure 7

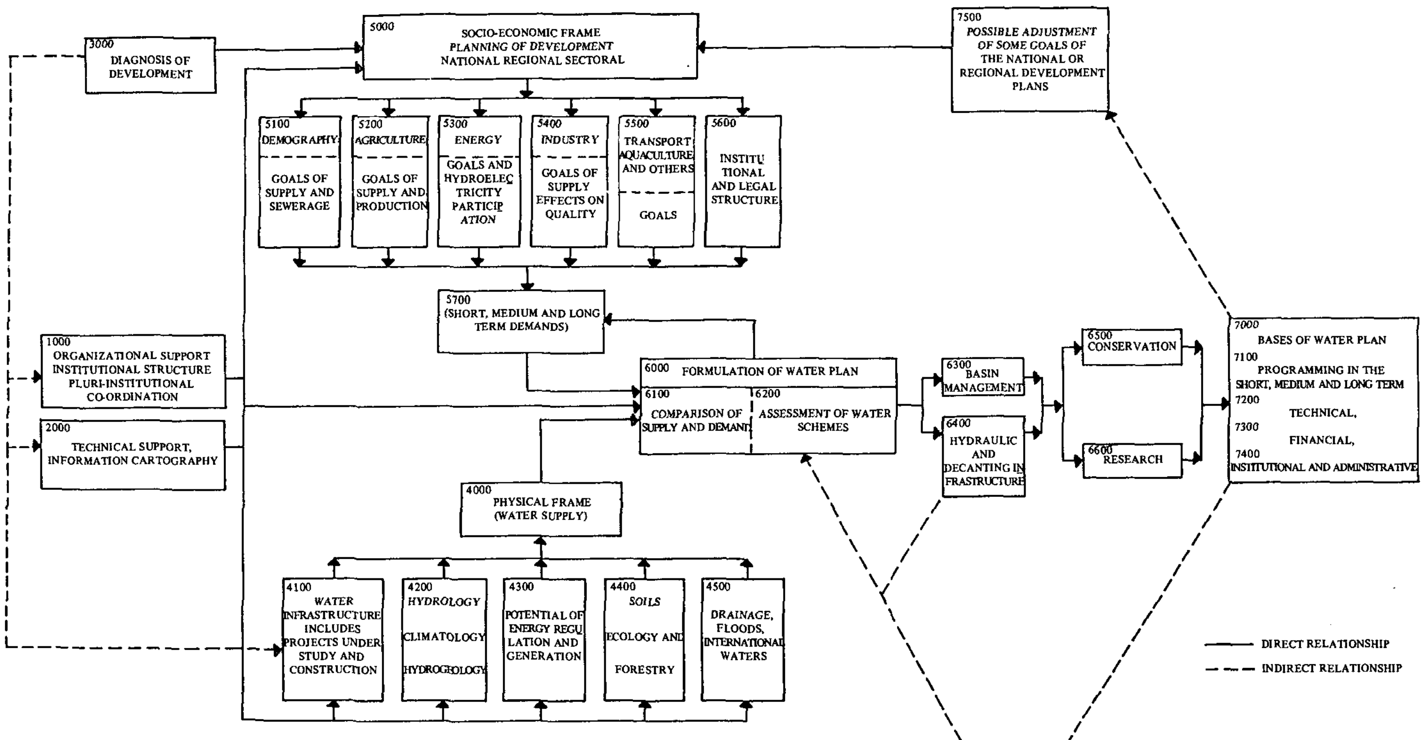
GENERAL DESIGN OF THE METHODOLOGY OF THE NATIONAL WATER MANAGEMENT PLAN OF PERU (1977)



Source: Comisión Multisectorial del Plan Nacional de Ordenamiento de los Recursos Hidráulicos, "Plan Nacional de Ordenamiento de Recursos Hidráulicos, Bases Técnicas y Económicas para su Formulación", Lima, Perú, 1977.

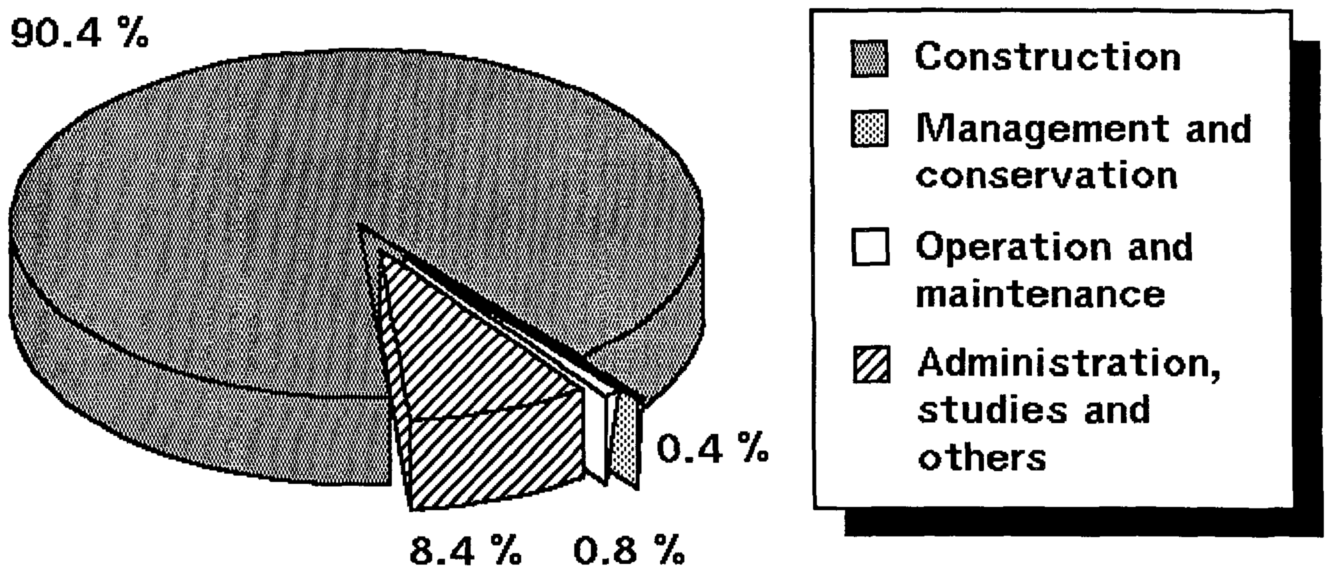
Figure 8

CONCEPTUAL DESIGN OF THE WATER PLAN OF ECUADOR



Source: Instituto Ecuatoriano de Recursos Hidráulicos (INERHI), "Marco general para la elaboración del plan nacional hidráulico", Quito, Ecuador, 1981.

Figure 9
PERCENTAGE DISTRIBUTION OF INVESTMENTS IN WATER RESOURCES



Note: investment budget of the Ministry of Agriculture and Food of Peru, 1979.

results in the gradual deterioration not only of the works themselves but, what is still more serious, of the renewable natural resources.

The subject-matter included in each of the plans reviewed follows the same pattern as the conceptual schemes indicated above. Obviously some countries lay more emphasis on certain aspects relatively more important in their countries. Nonetheless, some schemes and contents do not clearly differentiate the phase of diagnosis and procurement of the water balances from the phase of formulation of strategies or water policies resulting from these balances. In general they concentrate more on the water balances, which reduces the value of the plan. Other countries, in analysing water strategies or policies, merely stress the need to programme investment activities in hydraulic works, or sometimes they limit themselves to giving priority to hydraulic projects. This likewise diminishes the value of the effort made, since no consideration is given to other policy options or to an analysis of the possibilities of creating short-term policies aimed at the better use of existing water systems. It is evident that the plans are strongly inclined to formulate policies which facilitate an increase in the water supply, to the detriment of policies for controlling the demand.[33] These imbalances tend to correct themselves when the demand for water cannot be satisfied by new supplies of the resource, whether through shortage of water or of money to build new works. In these situations the imbalances have to be reduced through the formulation of policies limiting the use of water or increasing the efficiency of the existing hydraulic systems. These policies are usually adopted in face of situations which are naturally difficult to correct when no steps to prevent them have been taken in advance.

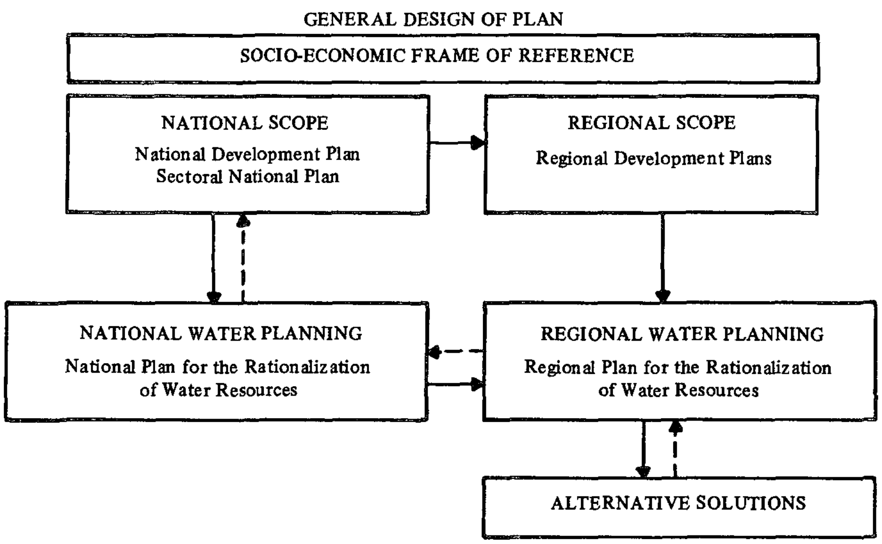
C. RELATIONSHIP BETWEEN NATIONAL WATER RESOURCE MANAGEMENT PLANS AND OTHER PLANS

1. National economic development plans and water resource management plans

Theoretical plans for water resource management (multisectoral, sectoral or subsectoral) should be formulated in close association with plans for socio-economic development. This co-ordination should also be made between national and regional plans. This harmony is very difficult to achieve in practice, so that it has seemed desirable to make a brief analysis of the subject. The aim is to try to discover, in a very tentative way, the degrees of relationship or integration that exist between water resource management plans and other plans. This has been taken as the starting point for the analysis of the water resource management plans available at national, regional and river-basin level, whether their intention is to plan or programme the execution of sectoral activities or multisectoral, as in the case of Ecuador (figure 10).

Figure 10

GENERAL DESIGN OF THE PLAN FOR THE RATIONALIZATION OF WATER RESOURCES OF ECUADOR



Source: Instituto Ecuatoriano de Recursos Hidráulicos (INERHI), "Plan de racionalización de los recursos hidráulicos", Términos de referencia, Quito, Ecuador, 1983.

The first step of the analysis was to try to identify the more usual difficulties found in co-ordinating socioeconomic development plans with water resource management plans.

Basically, the formulators of the national water resource management plans have had to face the following problems:

i) Lack of socioeconomic development plans in the country, region, microregion, locality and/or basin within which to establish the need to develop a water resource management plan.

ii) Socioeconomic development plans too incomplete for the establishment of water requirements and/or priorities for action in this field.

iii) Socioeconomic development plans with planning horizons shorter than those needed to plan the demand for water in the long-term, which is usually over 20 years.

iv) Spheres of socioeconomic development planning (as, for example, districts and communes) which do not coincide with the spheres required for the planning of water resource management (such as river basins).

Similarly, the most usual difficulties of harmonization in formulating a socioeconomic development plan at national or regional level incorporating water as a variable are:

i) Lack of diagnoses to determine the potential and real supply of water for different uses in the spheres of planning for socioeconomic development.

ii) Lack of alternative techniques (projects) for harmonizing water supply and demand at the point in time when the plans for socioeconomic development are being formulated.

iii) Existence of water resource management plans that are incomplete, through being excessively sectoral and limited in their strategies, and therefore unsuitable for use in plans for socioeconomic development.

iv) Lack of information on aspects relating to the administration of water resources, such as organization and the role of the State and of individuals in the administration of water, sources and forms of financing, potential of suitably trained manpower and the like.

The cause of these incompatibilities is the result of the different aims, clients, actors, conceptions and formulators of plans both in the field of water and in that of social and economic development.

The formulators of plans for water resource management at national, regional or water-basin level who have considered development strategies mainly to project their own demands, have resorted to several alternative solutions: recommending the execution of development plans which will serve the turn of information; designing, in co-ordination with the planning sectors, prospective models for water demand for 5, 10 or 20 years, and projecting, without any particular co-ordination, their own sectoral or subsectoral water needs. Most of the water projects in Latin America which aimed at increasing or controlling the supply of the resource unfortunately overlook development plans —even if they are available— and project their activities independently and in response to diverse interests, such as:

- Political pressures, mainly regional, to build works for hydroenergy generation, irrigation, flood control and the like.

- Investment interests on the part of State enterprises or departments, mixed or private, which in one way or another "sell" their line of business (sale of hydraulic equipment, pumping equipment, advisory services, etc.).

- Response to international or national "credit lines" which encourage investment with a view to the direct or indirect expansion of water use for certain sectoral purposes or interests, such as credits for irrigation in order to produce a particular crop.

In the first case described, that is, when the water project is in response to regional demands and is on a large-scale, the development planning has been conducted from below upwards, resulting from these demands. A typical evolution is to initiate a subsectoral project in the field of water such as, for example, an irrigation project through pressures from a region, which is then converted into a project of multisectoral water use, which may comprise irrigation, hydroenergy, fish-breeding, flood control and the like, which finally comes to represent a "Regional development project" or one for the "integral development of basins".[34]

In other cases, the water plans are formulated in "packets" or "investment lines" at national or regional level, and are aimed at the execution of only one type of activity in the water field, usually small in size but repeated on a large scale, such as small projects for irrigation, drainage, piped water supply, small hydroelectric power stations, etc. These plans, programmes or lines can also have a marked impact on the orientation of the development of certain regions or basins, in which they are applied without previous notice. What is more, it is very rare for these investment "packets" in the subsectoral water field to have any co-ordination among themselves, with the result that three or four investment "lines" can sometimes programme the use of the same water for different purposes.[35] These examples, which are very numerous, give rise to several factual conclusions as regards the region:

i) That it is necessary to strengthen all the intersectoral co-ordination systems in order to anticipate the multiple use of water. This measure of co-ordination should be reflected in programmes and plans of work in every basin or water-related region and should be used effectively as an administrative instrument at national, regional or local level.

ii) That these measures of co-ordination should be taken even if only to avoid serious conflicts in the use of water in the short, medium- or long-term and even when there is no immediate purpose of trying to "optimize" investments or the operation of already existing water systems or basin management.

iii) That water utilization for multisectoral purposes has taken place in the region almost always by successive stages and not as a result of previous planning, with the obvious ensuing problems and costs.

iv) That the national plans and programmes put into operation are mainly sectoral or subsectoral and almost always relate to the construction of hydraulic works. The sectors may incorporate multisectoral elements when their design has been completed. Hence the sectoral investment programmes, chiefly for hydroenergy, drinking water and irrigation, have been in many countries the driving and controlling element on the basis of which other activities in the field of water have gradually been developed. This accounts for the enormous influence of sectoral water plans on the national plans for water resource management.

v) It is evident, moreover, that in several countries plans for water resource management which incorporate strategies for reducing, controlling and/or administering the demand for water are very few or non-existent. There is an excessive tendency to build new works rather than to make existing ones function properly or to manage and conserve river basins or catchment areas, or to encourage efficiency among water users.

vi) Finally there is a need to improve the relationship and co-ordination between socioeconomic development plans —especially at regional and basin level— and plans for the management of water resources.

2. Sectoral and subsectoral plans for water use

In order to illustrate these points a review has been made of subsectoral plans in hydroenergy, agriculture and health (see table 7).

a) *Plans for hydroelectric utilization*

The South American countries which have completed inventories of hydroenergy resources as an initial phase in the formulation of plans for the use of these resources include Argentina, Brazil, Colombia, Chile, Ecuador, Peru, Uruguay and Venezuela. The Central American countries have similar studies and have also produced a joint project of electrical interconnection which includes hydro-electricity.[36] The other countries of the region are also in

Table 7

LATIN AMERICA AND THE CARIBBEAN: SECTORAL PLANS FOR WATER USE

Country	Multisectoral national plan	Name	Responsible body	Plan horizons, year	Year of formulation
		<u>Energy-hydroenergy sector</u>			
Argentina	No	Potencial hidroeléctrico estimado del país	Min. de Economía	2000	1979
Bahamas					
Barbados					
Bolivia	No				
Brazil	No	O potencial hidroeléctrico do Brasil	Min. Minas e Energía (ELECTROBRAS)	1990	1980
Colombia		Inventario Nacional de Recursos Hidroeléctricos	Depto. Nacional de Planificación	2000	1979
Costa Rica	No				
Cuba	Yes				
Chile	No				
Dominican Republic	No				
Ecuador	Yes	Plan Maestro de Electrificación	Instituto Ecuatoriano de Electrificación (INECEL)	1985	1980

Table 7 (cont. 1)

Country	Multisectoral national plan	Name	Responsible body	Plan horizons, year	Year of formulation
El Salvador	Yes				
Guatemala	No	Instituto Nacional de Electrificación (INDE)			
Guyana					
Haiti	No				
Honduras	Yes				
Jamaica	Yes				
Mexico	Yes				
Nicaragua					
Panama					
Paraguay	No		Adm.Nacional Electric. (ANDE)		
Peru	Yes	Evaluación Potencial Hidroeléctrico Nacional	Min. Energía, Minas, Dirección General Electrificación	-	1979
Suriname					
Trinidad and Tobago	No				
Uruguay	No	Evaluación Potencial Hidroeléctrico Nacional	Adm. Nacional Usinas y Transporte Elect. (UTE)	2000	
Venezuela	Yes	Inventario Nacional de Potencial Hidroeléctrico	Min. Ambiente y Recursos Naturales Renovables (MARNR)	1980	

Table 7 (cont. 2)

Country	Multisectoral national plan	Name
Argentina	No	
Bahamas		
Barbados		
Bolivia	No	Plan Nacional de Riegos
Brazil	No	
Colombia		
Costa Rica	No	
Cuba	Yes	
Chile	No	
Dominican Republic	No	
Ecuador	Yes	Plan Nacional de Riegos
El Salvador	Yes	
Guatemala	No	
Guyana		

	Responsible body	Plan horizons, year	Year of formu-lation
Agricultural sector			
	Min. Agricultura y Asuntos Campesinos (MACA)		
	Min. Interior/Min. Agricultura	1982/ 1986	1982
	Instituto Ecuatoriano Recursos Hidráulicos (INERHI)	2000	1979

Table 7 (cont. 3)

Country	Multisectoral national plan	Name	Responsible body	Plan horizons, year	Year of formulation
Haiti	No				
Honduras	Yes	Plan Nacional de Riegos y Drenaje	Min. Recursos Naturales, Div. Hídricos	2003	1978
Jamaica	Yes				
Mexico	Yes				
Nicaragua					
Panama		Plan Nacional de Riegos	Mín. Desarrollo Agropecuario		En formulación
Paraguay	No	Plan Maestro de Area de Influencia Yaciretá	Mín. Agricultura y Ganadería	-	1982
Peru	Yes	Opciones e inversiones prioritarias en el área de riego[a]	Min. Agricultura Instituto Nacional de Desarrollo		
Suriname					
Trinidad and Tobago	No				
Uruguay	No				
Venezuela	Yes				

Table 7 (cont. 4)

Country	Multisectoral national plan	Name	Responsible body	Plan horizon, year	Year of formulation	Name
			Health sector			
Argentina	No					
Bahamas						
Barbados						
Bolivia	No					
Brazil	No					
Colombia		Plan Nacional de Acueductos y Alcantarillado	Instituto de Fomento Municipal (INSFOPAL)	-	-	
Costa Rica	No					
Cuba	Yes					
Chile	No					
Dominican Republic	No					
Ecuador	Yes	Plan Nac. de Agua Potable y Saneamiento Ambiental	Instituto Ecuatoriano de Obras Sanitarias (IEOS)	2000	1980	Plan Multisectorial a nivel de términos de referencia
El Salvador	Yes					

Table 7 (concl.)

Country	Multisectoral national plan	Name	Responsible body	Plan horizon, year	Year of formu- lation	Name
Guatemala	No					
Guyana						
Haiti	No					
Honduras	Yes					Plan Multisectorial 1980-1987
Jamaica	Yes					
Mexico	Yes					
Nicaragua						
Panama						
Paraguay	No					
Peru	Yes					
Suriname						
Trinidad and Tobago	No					
Uruguay	No					
Venezuela	Yes					

[a] Proyecto Interregional del PNUD: INT/82/001.

process of forming plans, bearing in mind the ever increasing need to plan energy development. The hydroenergy inventory of the countries mentioned includes, as common elements of study, the following:

- estimation of the total hydroelectric potential of the country;
- estimation of the hydroelectric potential of priority basins;
- identification of hydrographic basins of special hydroelectric interest;
- compilation of basic information on hydrology, cartography, and geology for the whole country;
- preparation of a catalogue of hydroelectric projects, and
- estimation of the investment costs of the projects.

The average monthly flow of the rivers important for hydroenergy of Peru was estimated by using the hydrological model known as the HEC,[37] which has been modified for processing in a micro-computer, a system increasingly used in Latin America.[38] Argentina has a national plan for the equipment of systems of electric-energy generation in which it is emphasized that the water resource is still one of the most important sources of energy despite the fact that this country has developed several other forms of energy generation. With regard to hydroelectric energy, it is stated that "... according to the latest estimates the conventional hydroelectric potential technically usable in the country ie equivalent to the production of 200 000 kWh per year".[39] It is added that this potential would in itself alone suffice to meet the demand for electric energy up to the beginning of the next century.

In Ecuador, at the end of the 1970s, the Ecuadorian Institute for Electrification (INECEL) undertook planning studies for the electrical subsector, of which the basic objectives were to procure sufficient energy for the sustained development of the country and to create an efficient system of energy distribution. The activities ofINECEL included the study of hydroelectric resources, for which basic measures were proposed such as: to obtain topographical maps of the beds of all the rivers and their affluents, to draw up registers of water-flows and precipitations reflecting energy availabilities, and to ascertain the geological conditions of all the river beds. The Master Electrification Plan has a planning horizon of 20 years and adopts as a starting point a thorough knowledge of all hydroelectric resources. This includes a firm plan for the period 1980-1984. The objective of the short-term plan is that by the end of 1984 the country should have an installed capacity of 1 990 000 kW through an increase of 900 000 kW, of which 638 000 kW will be of hydroelectric origin.[40] Among the publications of INECEL on the subject of hydro-electricity the following may be mentioned "Catálogo de proyectos hidroeléctricos", March 1983; "Optimización de los recursos hidroeléctricos en el Ecuador", March 1983, and "Modelo matemático de regulación energética de cuencas hidrográficas".

The conclusions of the study on energy for Brazil are somewhat similar to those on Argentina; in fact, the Brazilian study points out that, according to long-term estimates (the first decades of the next century), the role of hydro-electricity will become even more important than at present or in the medium-term, since it is considered on the one hand that, although the cost of electric energy production through hydroelectric power stations will be greater, the cost of production through the use of fuel or nuclear fission will be greater still, and on the other hand, that the estimate of the water potential available may rise considerably in the coming years, which will increase its relative importance.[41]

As regards the Central American Isthmus, the Regional Project for the Electrical Interconnection of the Central American Isthmus comprises the study of the development of the electrical systems of the six countries of the Isthmus through the integrated operation of some 60 hydroelectric projects identified in the subregion in conjunction with thermo-electric and geo-thermal plants.[42]

Finally, it means repeating that it is hoped both in the near and distant future the generation of hydroelectric energy will increase its importance in the development of the countries. Fortunately the region has a very rich experience in the planning of hydroenergy resources and horizontal co-operation is promising in this field.

As can be seen from the foregoing, the programmes for the construction of hydroelectric power stations are designed and inserted within the national electrification plans, and, more generally, within the energy development plans. Nevertheless, as they are water-using installations, they ought also to be inserted within the general plans for water use so as to achieve integral utilization and avoid conflicts with other sectors interested in water use, such as irrigation, drinking water and sanitation, navigation, etc. This, however, has not occurred up to the present, basically owing to two facts: first, to the abundance of hydroelectric resources spread over wide areas of the continental countries; and, second, as a complement to the first, to the present possibility of transporting electric energy over great distances to the major centres of consumption. In this way it has been generally possible to select the places for energy generation in basins that do not conflict with other uses, some of which, such as water for sanitation (drinking water supply and sewerage) and irrigation, have priority importance over that of energy. At all events, if in a particular place there was simultaneous interest in energy and irrigation (which is another of the more important uses of water), it was usual to reconcile this by appropriate hydraulic works. In general, it has been the use of water for energy that has led to the creation or improvement of irrigation areas in many regions and not the reverse.

The fact that the hydroelectric sector has developed much more dynamically than the other water uses has made a very significant, almost crucial, contribution to the knowledge of the water resource in general by means of:

i) The formation of hydrological data banks, most of which are totally computerized.

ii) The development of hydrological models owing to the need to process a large quantity of information, which has compelled the use of computers and has given rise to the ensuing promotion of the preparation of computer programmes.

iii) The execution of a complete inventory of all the surface water resources of the country.

iv) The delimitation of river basins and the knowledge of their geology, which has contributed to the regionalization of the country.

At the same time the advance of the hydroelectric sector has been a factor in the formation of local personnel, trained in the compilation, analysis and processing of data.

The large programmes for the construction of hydroelectric power stations, along with the increasing demands for food and drinking water for the growing population of the region, could lead more and more to situations of conflicting interests. Nonetheless, the criterion prevailing at present in the design of hydraulic projects is that these should fulfill objectives of multiple use and meet the needs of all the possible sectors interested: energy, irrigation, drinking water supply, sewerage, navigation, recreation and flood control.

b) *Plans for water use in agriculture*

Plans concerned with the rational use of water in agriculture are generally aimed at programming irrigation and drainage activities, even though it is also necessary to incorporate in this classification the programming of measures to improve the use of water through water catchment from rain and mist —which are the basis of agriculture and stock-raising in rainfed agricultural zones— and the control of surface run-off.

Theoretically a national or regional irrigation and drainage plan should enable a government to programme the necessary measures for promoting the development of zones in the country suitable for this purpose, whether by stimulating private investment or adopting measures and making investments on its own account.

Plans of this nature are usually intended to achieve goals relating to a specific number of hectares which have to be irrigated or drained in a country region or basin. In these plans a distinction is made between the new areas to be incorporated and those which are already under irrigation or crops but can be improved. A distinction is likewise made between areas, which, although they receive a certain amount of rainfall or groundwater, need complementary irrigation, and those totally arid areas in which irrigation is the only possible source of water.

An irrigation and drainage plan adequately formulated should form part of a sectoral and agricultural plan and include the programming of physical-technical activities such as studies, projects, works and operation of hydraulic systems. It should also include politico-administrative activities, such as the adaptation of regulations, credits, training, organization and other aspects directed towards the good use and conservation of water in agriculture.

In practice it is difficult to make a large-scale irrigation and drainage plan which will comprise all the aspects mentioned, so that it is usual to resort to the formulation of specific programmes and projects. In this respect it is of interest to outline the different motivations and means that tend to be involved in the promotion of irrigation and drainage development in Latin America and the Caribbean.

Taking as an example only two countries, Peru and Brazil, it can be seen, *inter alia*, that the motivations and means employed comprise aspects in common, such as:

i) Promotion of the execution of large irrigation and drainage projects based on objectives of regional development and integral development of large basins, such as the irrigation projects of the Companhia do Desenvolvimento do Vale do Sao Francisco, Brazil[43] and large irrigation projects on the Pacific coast of Peru.

ii) Promotion of the execution of medium-sized and small irrigation projects based on the stimulation of:

- the utilization of certain soils or geographic areas, such as the PROVARZEAS Project in Brazil;
- the utilization of certain water resources, such as the Project for the Enlargement of the Agricultural Frontier with Utilization of Groundwater, on the coast of Peru;
- the utilization of community participation and the generation of employment, such as the Irrigation Projects with Community Co-operation, in Peru;
- the benefiting of certain geographic areas, such as the

Plan for Irrigation Improvement in the Sierra, PLAN MERIS, of Peru;
- the promotion of certain crops through the allocation of credit for irrigation, such as the credits for the sowing of rice in Brazil;
- the promotion of the use of specific technologies, such as the credits destined for the purchase of pumping machinery or equipment for irrigation by sprinkling and dripping;
- the promotion of certain technical or administrative measures, such as, for example, the improvement of the use made of irrigation areas, etc.

This list exemplifies sufficiently clearly that irrigation and drainage are promoted and developed according to very different rationales and patterns and in very different institutions. Although this is not necessarily an adverse factor there are at least some basic aspects that should certainly be considered by the governments if they are to contribute to the orderly development of irrigation and drainage in their countries. Among these aspects the following should be mentioned:

i) To ascertain the potential of the areas suitable for total or complementary irrigation and drainage, including their irrigation needs and availability and the demands for the washing of soils or the drainage of humid zones, in order to rank their utilization in terms of the country's development goals and thereby to select the most suitable projects for investment.

ii) To ascertain the present state of the hydraulic systems already built for irrigation and drainage and the efficacy of their functioning and maintenance so that the government may assist their users, for example, to improve the irrigation or drainage areas.

iii) To ascertain the state of the management and conservation of the water and soil resources of the whole river basin and not only of the perimeters irrigated. In particular the governments should inform themselves of the problems of water-logging, salinization, erosion and contamination, in order to programme activities which will forestall these effects or rehabilitate degraded resources.

iv) To ascertain the way in which the resources of the State are distributed in the promotion of irrigation and drainage: a) by geographic areas, b) within the agricultural sector, c) between research, building of works and operation of systems, and d) between irrigated and rainfed areas, in order to avoid serious distortions in the allocation of these resources.

v) To learn how the legal, institutional, financing, educational and budgetary systems, among others, effectively help to promote and facilitate irrigation and drainage in the country, along with the efficient use of rain water in rainfed zones.

It has been noted that several Latin American countries, aware of the need to foster the use and management of water in agriculture, have developed specific strategies to this end. The countries which have been longest in this field, such as Mexico, Peru, Chile and Argentina, in addition to their traditional policy of irrigation expansion, have now begun to consider the following:

i) A more balanced distribution of resource allocation for irrigation and drainage within their territory, avoiding the excessive benefit of certain regions, as in the north of Mexico and on the coasts of Peru, to the detriment of other regions in the country.

ii) A more equitable distribution of resource allocation for water management among irrigation zones, drainage zones and/or rainfed zones. In particular this last head should be duly considered with a view to improving upper-basin management, collect more rain water with better physical development of the land, and control run-off, erosion and floodings.

iii) The allocation of more resources to the operation and maintenance of existing hydraulic systems, together with the management and conservation of water and soil in the areas of irrigation and drainage, which comprise, as in Peru, the whole of one or more hydrographic basins.

Brazil, whose experience in irrigation and drainage is relatively recent in Latin America, intends to expand its irrigated surface from 1 100 000 to 3 000 000 hectares, for which it has drawn up a draft project called "National Irrigation Plan 1982-1986",[44] which seeks to rationalize this activity at national level, and which constitutes a very positive step towards the promotion of this activity. In some of the States of the Northeast, such as Piauí, there have even been specific programmes for the promotion of the multiple and rational use of water with emphasis on irrigation.[45]

In Venezuela irrigation is relatively less important than the drainage zones with an excess of water. Hence the government is more interested in supporting the execution of drainage projects. Venezuela has an area of 1 227 000 hectares drained and 323 000 hectares irrigated.

Practically all the other countries of the region are equally concerned to improve the efficiency of water use in agriculture and it is to be hoped that co-operation among all the governments and specialists of the region will facilitate this objective.[46]

c) *Drinking water supply plans*

For a long time past the Latin American governments have recognized the importance of providing drinking water and sewerage services for their populations as a vital factor for the preservation and improvement of health. There has been considerable progress, particularly in recent years. Thus, for example, whereas 20 years ago only 60% of the urban population and less than 8% of the rural had access to a drinking water supply, in the year 1977 some 75% of the urban population and 34% of the rural had reasonable access to drinking water (although only 43% of the urban and 3% of the rural population had an adequate sewerage system).[47]

More recently, the International Drinking Water Supply and Sanitation Decade, sponsored by the United Nations (1980), was instrumental in causing all the countries of the region to include within their planning activities the development of drinking water and sewerage systems for their populations both urban and rural. Particularly important is the assistance being provided by the World Bank, the World Health Organization and the Pan-American Health Organization in the achievement of the goals of this Decade.

A recent survey conducted by the Pan-American health Organization (PAHO) revealed that all the 20 countries surveyed had set their goals for the International Drinking Water Supply and Sanitation Decade at the end of 1982.

All the countries surveyed have set themselves goals for urban household connection to water systems; nonetheless, less than half have fixed goals for household connections in rural areas, so that the situation of the peasantry remains particularly difficult in the region.

The sewerage systems in the rural area are the least developed and there are no statistical data on the subject in many countries. In the region as a whole, however, the situation is diverse. Three groups of countries can be distinguished in accordance with the proportion of rural population existing now and projected up to 1990:[48]

- countries with under 20% of rural population (Argentina, Chile, Uruguay, Venezuela);
- countries with 20% to 35% of rural population (Brazil, Colombia, Cuba, Mexico, and Peru), and
- countries with over 35% of rural population (the remaining countries).

As regards the organization of the drinking water and sewerage sector in the countries of the region the study has revealed that there is generally one institution responsible for supervising measures and planning at national level. Nonetheless, the drinking water and sewerage services of some large cities, such as Mexico, Lima, Bogotá, Guayaquil, Quito, etc., through having services which supply very large communities, as for example Mexico City (14 million inhabitants), have considerable autonomy in the formulation of their plans.

The drinking water supply services for the urban areas of several thousand inhabitants generally depend on the aforesaid institutions or on the municipalities or local governments, while the drinking water and sanitation services for rural populations ranging from a few hundred to a few thousand inhabitants depend on the ministries of health.

This division of duties seems to function very well in all the cases analysed, but it hampers the execution of drinking water supply plans at national level.

The cases of Argentina, Brazil, Colombia and Ecuador are examples of the different ways in which the countries have organized their water supply and sanitation service.

In Argentina the main responsibility for the sector is in the hands of the Ministries of Public Works and of Social Welfare. In the former, the Subsecretariat for Water Resources has legal control of the *Empresa de Obras Sanitarias de la Nación* and the *Servicio Nacional de Agua Potable y Saneamiento Rural*. The second includes the Secretariat of State for Public Health, within which the *Dirección Nacional de Saneamiento Ambiental* is responsible for the preservation of the environment.

The *Empresa de Obras Sanitarias de la Nación* attends to the needs of 80% of the population which has a drinking water supply service and 90% of that which has sewerage, and is the main body in charge of the implementation of the policies and plans of the National Government for the sector.

The *Servicio Nacional de Agua Potable y Saneamiento Rural* was established in 1964 and was put in charge of the promotion, supervision and administration of the national plan for rural water supply and sanitation.[49] Under this plan, which at present extends to localities of up to 10 000 inhabitants, the intention is:

- in the short-term, to provide a drinking water service for 400 000 inhabitants of rural communities;
- in the medium-term, to meet the water supply needs of 1 700 000 inhabitants;
- in the long-term, to provide services for the whole of the rural population, i.e., for 4 400 000 inhabitants within the next 20 years.

This plan which has the financial support of the Inter-American Development Bank (IDB), has been very successful and has fulfilled its goals, in which an important factor has been the participation of the same rural communities which have benefited from the projects of the plan.[50]

In Brazil the Ministry of the Interior has a Departamento Nacional de Obras Sanitarias (DNOS), which acting at the national level —not counting the Polígono de la Sequía— includes the following among its aims and objectives:

i) To establish norms and specifications for the drawing up of projects, the execution of works for the operation and conservation of basic sanitation services, especially a water supply, rainfall drainage and waste disposal; control of the contamination of the sea shore, in masses and water courses; control of erosion, improvement of areas and their protection against drought and flooding.

ii) To prepare studies and projects, as well as to guide, supervise and implement directly or indirectly works and services of irrigation and rural and urban sanitation, both general and basic, in collaboration with the States, territories and municipalities, and public and private bodies, in accordance with the regional development plans.

In the case of Ecuador, the year 1980 saw the beginning of the formulation of the bases of the Ten-Year Plan for the Supply of Drinking Water and Sewerage for the urban and rural zones of the country. For the period 1980-1984 the following goals were envisaged: i) to increase the water supply coverage to 65% of the population in the urban zones and 25% in the rural and, as regards sewerage, to increase the coverage to 80% in the cities and 30% in the countryside; ii) to construct in the urban zones 47 drinking water supply systems and 74 sewerage systems, both for rain drainage and waste disposal, and iii) to execute 400 joint projects of basic rural sanitation.[51]

Colombia has the Plan Nacional de Acueductos y Alcantarillados (PLANAL), which contemplates a set of measures aimed at the structuring of a coherent policy at national level and gradually to increase the coverage of the services to all the communities in the country.[52]

In conclusion, it may be said that the region has made progress in the preparation of plans and programmes for the rapid growth of water supply and drainage services during the International Drinking Water Supply and Sanitation Decade. The problem of tackling and implementing these plans and programmes, however, is still to be resolved. The recognition that there are numerous obstacles, particularly in respect of available finance and trained personnel for the achievement of these goals, shows that the countries of the region are aware that this challenge is very difficult to overcome. Undoubtedly the financial situation of the sector has been to some extent self-imposed owing to the failure to fix a charge which would adequately recover the costs of the service.[53] It has been said that technological innovation would be one solution; it is obviously not the panacea, however, particularly for the solution of the problem of lack of funds. The problem can only be finally solved by means of good administration. This should include the adoption of a stable policy for the sector, the application of long-term strategies for the development of the sector, the provision of well-trained personnel at all levels, but above all the operation of programmes to serve the rural population and the maintenance of rational management practices to conserve existing installations and maximize their utility.[54]

d) *Planning at the basin level*

There is a long tradition of basin planning in Latin America; at first it was centred almost entirely on the exploitation of the water resources, but recently it has been giving greater consideration to environmental aspects. These considerations are of more recent date, and have been particularly assisted by the Organization of American States (OAS) through its Regional Planning Department. Particularly important is the support given by this organization to the development of international hydrographic basins. From 1960 to 1982 this Department has conducted projects in several countries in the field of watershed development for multiple use[55] (table 8). Moreover, each country, using this or some other form of technical assistance or by its own means, has drawn up different plans of development for its hydrographic basins. Different approaches and different emphases have been formulated in accordance with their socioeconomic situations. The following cases are mentioned by way of example or for purposes of comparison.

a) In Ecuador there are numerous study projects for the utilization of basins, in which the water resource has been emphasized:[56]

i) Study of the northwestern basins; planning of the exploitation of the land and water resources in the basins of the rivers Esmeralda and Santiago.

ii) Draft plan for the integral development of the basin of the river Pastaza, aimed at formulating a diagnosis of the natural and socioeconomic resources over an area of 22 000 km2, stressing irrigation, drainage and hydro-electricity.

Table 8

TECHNICAL CO-OPERATION ACTIVITIES OF THE OAS IN THE DEVELOPMENT OF RIVER BASINS

No.	Activity	Date of study	Date of publi-cation
1.	Integrated assessment of natural resources: development possibilities of the basin of the river Guayas, Ecuador	1962	1964
2.	Development of the water resources of the basin of the river Santa Lucía, Uruguay	1969-1970	1971
3.	Assistance for the planning of river basins, Venezuela	1971-1973	-
4.	Study of the lower basin of the river Bermejo, Argentina	1973-1975	1978
5.	Regional development of the basin of the river Esmeraldas, Ecuador	1973-1976	1977
6.	Assistance for the planning of river basins, Peru	1975-1976	1976
7.	Study of the integrated development of the basin of the Alto Paraguay, Brazil	1977-1981	1981
8.	Environmental Quality and River Basin Development: A model for integrated analysis and planning, river Bermejo, Argentina	1975-1976	1978
9.	Irrigation projects in Canelón Grande and Aguas Blancas, Uruguay	1977	1977

Table 8 (concl.)

No.	Activity	Date of study	Date of publi-cation
10.	Programme for small dams, Dominican Republic	1978-1979	-
11.	Integrated development of the Paracatú basin, Brazil	1978-1980	1980
12.	Project for the Jatobá basin, Brazil	1978-1980	1980
13.	Project for the integrated development of the Araguaia-Tocantins basin, Brazil	1981	
14.	Agricultural development under irrigation in the Upper Basin of the River Pilcomayo (MACA), Bolivia	1980-1982	
15.	Regional Development Planning, Suriname	1979-1981	
16.	Advisory assistance in regional and physical planning for the Ministry of Planning and Co-ordination (CORDIPLAN), Venezuela	1979-1981	
17.	River basin planning, Ecuador	1982	

Source: OAS, "Actividades de cooperación técnica", Departamento de Desarrollo Regional, Energía y Recursos Naturales, Washington, D.C., 1981.

iii) Development plan for Region 1, directed to the use of the water resources in the basin of the rivers Santiago and Mira, and a development plan for the provinces of Esmeraldas, Imbabura and Carchi.

iv) Plan for the upper and intermediate basins of the rivers Jubones, Cañar and Paute, including a draft plan for the utilization and management of the hydrographic basins.

v) Hydraulic plan for the Jubones basin, which forms part of the planning project for the hydrographic systems (with the OAS), one of whose objectives is the execution of studies and proposals for the rational development and multiple use of the water resources.

vi) Development plan for the Guayas basin.

b) In Brazil, in view of the importance assigned to the integral development of basins, it has been arranged that the management of water by hydrographic basins or sub-basins should be carried out through an agency which will reconcile the presence of all the parties involved in the water resources, harmonizing the central organs and entities and their counterparts at State and municipal level. This agency is the Special Committee for Integrated Studies on Hydrographic Basins (Comité Especial de Estudios Integrados de Cuencas Hidrográficas (CEEIBH)) formally created in March 1979.

The CEEIBH is in charge of the classification of the water courses of the Union, the integrated study and supervision of the rational use of the water resources of the hydrographic basis of the federal rivers, in the sense of obtaining multiple benefit from each one and minimizing the harmful effects on the ecology of the region.

The members of the CEEIBH are the Secretary of the Special Secretariat for the Environment MINER/SEMA, the Director-General of the National Department for Water Resources and Electric Energy, MME/DNAEE, the Director President of the Brazilian Electric Power Stations S.A., MME/ELECTROBRAS, the Director General of the national Department for Sanitation Works, MINER/DNOS, the Superintendent of the Regional Development Superintendencies in the respective geo-economic area of the hydrographic basin of the federal rivers, and the Secretaries of State nominated by the Governors of the States whose governments have special powers over the control of the environment and water resources in the respective hydrographic basin of the federal rivers.

Moreover, considerable experience has been accumulated as a result of the development project for the basin and valley of the river San Francisco (640 000 km2), which was initiated in 1964.[57] This is a multiple-use and far-ranging project. Other projects are those of the Araguaia-Tocantins basins and the Jatoba basin.

Particularly in the latter project, the integrated development programme includes, *inter alia*, utilization of groundwater, fish-breeding, improvement of rainfed agriculture, educational programmes, health, drinking water and sewerage supply services and community development. The Superintendency for the Development of the Northeast Region (SUDENE) and the Government of the State of Pernambuco have initiated the works and assigned the respective funds for the period 1980-1983. The pilot study and its follow-up measures are used to orient a general development strategy for the semi-arid region of the Northeast.[58]

c) Colombia also, through its various corporations for regional development, has wide experience in the planning of river basins. One of the oldest of these bodies is the Autonomous Regional Corporation for the Cauca Valley (CVC), which was created in 1954 to develop the upper part of the Cauca Valley and its surrounding areas. At first the CVC centred its efforts on the development of hydroenergy, in order to create resources, but now it conducts multiple projects including flood control, irrigated agriculture and electricity generation as in the case of the Salvajina project.[59]

d) In Peru there are several agencies in charge of the study, development and/or management of the resources of the river basins. In this respect, i) various studies have been carried out to assess, at basin level, the natural resources of the country, the study on the coastal basins having now been completed (National Office for the Evaluation of Natural Resources (ONERN); ii) there are special projects for water development at basin level by sectors: for energy, the projects of the basins of the rivers Mantaro and Huallaga; for agriculture (irrigation), the projects of the basins of the Chira-Piura, Puyango-Tumbes, Cajamarca, Mantaro, Alto Vilcanota, Chumbao, etc.; for drinking water and energy, the project for decanting the Mantaro river; iii) the water management is conducted at basin level through the Irrigation Districts which depend on the Ministry of Agriculture; iv) there are special projects for regional development at basin level, such as those of the Huallaga and Alto Mayo; and v) finally, there are systems of control of natural conflicts likewise at basin level, such as those of the Santa Corporation, in the Department of Ancash.

It can be seen that there is a wide range of possibilities for undertaking and carrying out the development of river basins in Latin America and the Caribbean; moreover, several basins have been incorporated for the integral planning of a region, as in the case of the "micro-regions" of Mexico, in which the planning was carried on under the direction of the agency known as the Public Investment

Programme for Rural Development (PIDER), which came under the Ministry of Planning and Budget.[60]

An important conclusion that can be drawn is that some very intensive and far-reaching work is in progress on the planning of water use at basin level, which because of its character as a biogeographic unit is better suited than plans at national level to produce a really effective development of this resource.

D. CONCLUSIONS

1. The importance of planning in the region

One of the immediate results of the execution of a water utilization plan is to make manifest the role of this resource in the development of a country or region. In order to formulate a plan for the use of water resources this must necessarily form part of the development plans of the country, so that in those countries where there are water problems territorial management must be associated with the regionalization of water, in view of the close relationship between water use and development.[61]

The need to prevent conflicts in the use or control of water is certainly more evident in areas which have a high potential growth in respect of population, industry, agriculture, energy, etc., and which are situated in arid or high-altitude zones that have little available water, are subject to droughts or floods and have pollution or other problems. In Latin America this combination of conflictive areas is frequent, owing to the unequal distribution of the resource, to the phenomena which affect them and the growth of demand.

Many of these areas, in their turn, have related problems such as the settlement of communities high above sea-level, which reduces the water catchment area and/or causes the discharge of polluted water to affect communities downstream through the occurrence of long periods of drought interrupted by heavy rains and other extreme phenomena such as landslides or other erosive processes.

Flooding, at least in recent years, has led to the planning of water resource control. The north of Argentina, Paraguay, the south of Brazil, the north of Peru and Ecuador were the areas most widely afflicted in the region. In the Caribbean and the Gulf the hurricane phenomenon is equally well known. In addition, the problems of water pollution control in urban areas are increasingly acute. These situations leave no doubt as to the need to regulate the use of the resource and thus orient a policy of water control.

2. Effects of the formulation of plans on water resource development

According to the comparative analyses of plans and their results, it may be concluded that the drawing up of a national plan for the management of water resources is useful:

- during the process of drawing up the plan, and
- once the plan is completed.

At the risk of exaggeration, it might be said that the two stages are equally important. The stage of formulation of the plan is in many cases the first step towards an institutional co-ordination previously non-existent in several countries. A sample of this integration can be found, for example, in the composition of the Commission on the National Plan for Water Resource Management of Peru. Another example of the importance of the preparatory stage can be found in the achievements during the formulation of the Master Plan for Water Resource Development and Utilization of El Salvador. This includes, among other projects, the creation of a specialized water department in the Ministry of Planning in 1981, the drawing up of draft project on Water Law, and the creation of a data bank on water resources. Similar examples of benefits are found in the formulation stage of almost all the plans that seek the active participation of the State agencies and the water users themselves, as in the case of the Water Plan of Mexico.

The fact of possessing a completed plan marks a new stage which is by no means definitive in view of the need for a permanent feedback to the system created. The most important aspect of this stage is the possession of an articulated functional system which facilitates the taking of decisions on the utilization and management of water for development. The form in which the plans are applied in practice must certainly be carefully assessed before their real scope can be determined, a task which will entail a deeper study than the present one.

3. Strategies for strengthening the national and multisectoral planning of water resources

A national plan for water use must necessarily cover the long-term, and embrace a series of economic sectors and the whole territory of the country, which means that it may encounter many obstacles that hinder or delay its preparation and application. To avoid this situation it is suggested that a strategy be adopted which includes the following aspects:

a) It should permit the execution of sectoral plans for water use, but with co-ordination, particularly at the level of basins or basin systems. In this connection precautionary measures should be taken to keep a record of on-going studies and projects programmed in relation to each basin. This record should serve as a register of supply and demand. Any new demand should be duly registered as an indication of possible conflicts.

b) Planning should be fostered for the management of water resources at the level of a river basin or of inter-linked basin systems. This is more advisable than planning by sectors since the result is more easily incorporated into a national plan.

c) A system of interinstitutional co-ordination should be formally established with its own budget. This system (commission, secretariat or the like), which should be permanent, is fundamental for the co-ordination and stimulation of interinstitutional participation both during the formulation and during the application of the plans.

d) It is politically important that the plans should take short- or medium-term measures into account as well as long-term measures, in order to obtain support and consideration from the government system and the specialized sectoral institutions.[62]

e) It is important to foster public participation, through the operation of information and extension systems which seek to stimulate the participation of the water users in the processes of management. In this regard an observation by Azpúrua and Gabaldón may be quoted, which states that "public participation is an essential condition for improving the use and preservation of water, and becomes even more important in situations of water shortage or emergencies caused by droughts or floods. The experiences of other countries show that, in conditions of drought, the population has reduced its water consumption by as much as 50% when it has been made aware of the value of water, the problem to be faced and the measures for its solution, a result which has been achieved through intense publicity campaigns. This public awareness can then be transformed into a form of support for the efforts made by planners in the development of water resources".[63]

4. State of progress in water resource management planning in Latin America and the Caribbean

A total of eight countries in the region have formulated or are in the process of formulating plans for the management of their water resources at national and multisectoral levels: Colombia, Ecuador, El Salvador, Honduras, Jamaica, Mexico, Peru and Venezuela. Another two countries, Argentina and the Dominican Republic intend to initiate them in the future.

Practically all the countries of the region have formulated one or more plans for the management of their water resources, which have had national but not sectoral coverage. These plans mainly relate to the subsectors of hydroenergy, irrigation and drainage, and drinking water supply and sanitation. The formulation of plans in this last subsector was stimulated by the International Drinking Water Supply and Sanitation Decade.

All the countries of the region have experienced in the formulation of plans for the multiple or sectoral utilization of water at river basin level, both national and international. At national level, for example, there has been the formulation of plans for the development of the valley and basin of the River San Francisco in Brazil; the valley and basins of the River Cauca in Colombia and the basin of the River Guayas in Ecuador.

In some countries sectoral plans, mainly directed to energy or irrigation, have completely dominated strategies in the field of water. In these cases a single sector directs the water management plan and is so strong that it comes to have influence and priority even in the activities of regional or national development.

a) *Procedures used in the formulation of plans for water resource management*

i) The most frequently used measure has been the creation of "national co-ordination commissions" to formulate the plan. The members of these commissions are usually the directors of the different water-using sectors and have some type of executive secretariat. The head of the commission is generally a representative of the central planning sector or of a body responsible for the management of the resource (agriculture, environment) or of an institute specialized in water resources.

ii) One of the main benefits obtained on the initiation of a plan of national and multisectoral nature is the very fact that a national mechanism to co-ordinate water-resource activities is set up which was previously non-existent. This applies equally to planning processes in regions or in river basins.

iii) For a co-ordination commission to be successful it needs: a) to be created and to function at the highest level; b) to have a specific budget to formulate the plan; c) to have an executive secretariat with permanent staff, and d) to have the effective participation of all the sectors involved in the formulation of the plan. As regards this last point, it may be said that if the user sectors do not participate in its formulation it is most unlikely that the plan will be taken into account in practice and the effect of an awareness of the multisectoral use of water will also be lost. Thus it is indispensable that the members of the commission should be the directors or heads of each user sector and not a representative.

b) ***The structure and content of water-resource management plans at the national and multisectoral levels***

i) It has been noted that the structure of the plans follows a uniform pattern: in a first phase the water-related regions are marked out; in a second phase a diagnosis is made which includes the study of the water supply and demand in each region and among water-related regions for different time horizons; and in a third phase, strategies or policies are formulated to harmonize water supply and demand in the short, medium- and long-term.

ii) A plan without strategies or policies for the harmonization of water supply and demand should not be regarded as such. In practice, however, there are numerous documents under the name of plans despite the fact that they merely reach the diagnosis phase. Moreover, several plans which incorporate strategies limit themselves to a consideration of alternatives for increasing the supply of water through giving priority to investment in hydraulic works, and do not present alternatives for the regulation or control of the growth of demand for water, that is, for an increase in efficiency in the use of the systems constructed or a setting of limits to growth in specific urban, industrial or other areas.

iii) The so-called "incorporation of the environmental dimension" in the plans has a varied scope. In actual fact it is not an explicit or integral incorporation, even when it is directed to the management and control of environmental aspects such as water pollution problems (which affect health), problems of erosion and sedimentation, problems of land salinization, problems of overexploitation of groundwater aquifers and saline intrusion and problems concerning the conservation and preservation of water for ecological purposes.

iv) In almost all the plans, excepting the Water Plan of Mexico, too little consideration is given to the design of strategies for the operation and maintenance of hydraulic works in existence and the management and conservation of water resources, particularly in the catchment areas of rivers. This is reflected in the meagre budgetary allocation of the governments to the performance of these activities, which contrasts with the high investment assigned to the construction of new hydraulic works.

c) *The relative usefulness of water-resource management plans*

i) A plan for water-resource management will be useful to the extent that it is used to take decisions which favour the socioeconomic development of a country or region and to avoid or prevent conflicts in the use of water. The policies that can be applied for this purpose, as was mentioned above, are aimed at increasing and controlling the supply of water and managing or controlling the demand.

ii) It is evident, however, that management plans in the region have been formulated or utilized almost exclusively to direct investment policies to increase the water supply and hardly at all to control the demand for water. Hence it can be stated that what has been done hitherto in the field of water-resource management has been insufficient to avoid or prevent conflicts arising from an exponential growth in demands for water and to mitigate the effects of natural phenomena such as floods, droughts, and pollution problems.

iii) Nevertheless, it is clear that the increase in the demands for water in quality and quantity, above all in the large urban centres, can no longer be met merely by the construction of new and more costly hydraulic works. The solution inevitably calls for the application of strategies combining these works with a reduction in the demand. This reduction implies the creation of alternatives for improving the efficiency of water use, along with other more drastic measures to restrict its growth. The countries should draw up and establish this type of alternative in order to achieve a real "management of the resource" in their territories.

iv) Experience shows that despite the availability of national plans for water-resource management, including the most complete and ideal, there has been no guarantee of their application. This is mainly due to the scant political usefulness of the plans, particularly when they suggest measures for controlling demand, as for example, through an increase in water charges, population redistribution, crop displacement, embargoes on the use of groundwater and other types of rationing. As regards the increase of the water supply, the most effective measure has apparently been the formulation and application of management plans for river basins or regions or for water-using sectors. In most of these cases the plan or programme is based on one or more concrete projects which are already accepted by public opinion or existing policies. The plan then serves to make requests viable and to incorporate complementary strategies.

v) It is also clear that measures for restricting demand have been applied in the region only when the situations of conflict in the use of water have become untenable, as in periods of drought and in general when demand exceeds supply. On these occasions strategies are put forward which should have been applied before in order to avoid the problem. This reveals a need for greater political and public awareness, in order to prevent conflictive situations. This promotion of awareness, in order to prevent conflictive situations. This promotion of awareness should therefore be a fundamental part of the formulation of the plans.

vi) It is obvious, that several of the plans are not politically viable because they do not include strategies for a specific government period. Generally speaking they are only concerned with planning-long term measures, without establishing a sufficient nexus between these measures and those of the short- and medium-term, that is, with the government in power. This lessens the political weight of the plan since no account is taken that long-term measures must be initiated in the short-term.

vii) In practice a government has very little choice in the construction of large water projects, mainly because it inherits those already initiated under previous governments, but it can certainly make considerable improvements in the efficacy of water use and carefully programme the commencement of new works. This should be taken into account in order to improve the probabilities of application and facilitate the procurement of support for the implementation of the measures recommended.

viii) None of the above statements invalidate the importance and necessity of drawing up national plans for the management of water resources; on the contrary, they confirm the need. It is obvious, however, that the application of the plans can and should be improved, by implementing, in its context and with greater scope, the phase of formulation of strategies or policies and, within these, by giving more consideration to the strategies for the control of water supply and demand, in order to provide viable alternatives to the policies, and to create a public consciousness of the importance of water as a vital factor for development.

d) ***Linkages between water-resource management plans and socioeconomic development plans***

i) In most of the plans for water-resource management studied there has been no clear linkage with those for socioeconomic development. This lack of association is particularly observable in the need felt by the planners to project the demand for water in the medium- and long-term by resorting to the formulation of their own prospective models.

ii) In regions where socioeconomic growth has depended heavily on the control and use of water —as in arid or semi-arid zones or in flood-prone areas— it is noteworthy that the plans have concentrated on creating alternatives for exercising this control. Subsequently, and only when the restriction of water has reached its limits, have plans been undertaken for regional development. In these cases regional planning has been adapted and conditioned to the plans for water management.

iii) In some sector, especially those of energy and agriculture, the perfecting of demand projects has continued along with the selection and ranking of zones in which the projects can be established. In these cases the relationship between water management plans and development plans is more precise. The progress made in the formulation of plans for water resource management by sectors facilitates the improvement of this relationship.

iv) As long as there is a lack of instruments to improve co-ordination between socioeconomic development plans and water resource management plans, it is advisable that there should at least be a record kept of water supplies and demands —actual and projected— in each river basin or water-related region, including all the existing and proposed projects for harmonizing these supplies and demands. The permanent register of projects according to basins will at least help to avoid conflicts on the multisectoral use of water in the region.

Despite the powerful reasons put forward in favour of planning, there are few signs that this had any significant influence on the policies for the development and management of water and water-related resources or on the application of these policies. Although there are no studies on the linkage of the national plans for water resource management with the decision-taking on policies and their application to the development and management of these resources, specific observations made on what has happened in the water sector in the region would support the opinion of the sceptics, outlined in the introduction to this paper, to the effect that the plans are frequently not inserted in the decision-making process which determines the way in which renewable resources are administered in practice. These observations include the unco-ordinated use for a single purpose of the same water resource by independent users; the scant attention paid to questions which have a bearing on the degradation of the upper river basin; the great importance attached to new capital projects at the expense of the performance and maintenance of existing projects; the tendency to concentrate resources on large projects and to overlook opportunities for achieving a greater dispersion and mobilization of local initiative; the importance given to increasing the supply of water-related services without paying due attention to policies which regulate demand and stimulate an efficient use.

This study has insisted, on the basis of well-founded arguments, on the importance of the planning of water resources at all administrative levels. There must be integration between these levels and the planning itself must be integrated with that of other renewable resources; it is likewise necessary to establish concrete linkages with the national and regional plans for economic development. Very considerable resources are devoted to the planning of water use in the region, although it is far from clear whether the resulting plans lead to the adoption of more efficient decisions on the utilization and management of water from the standpoint of the objectives of economic and social development.

A systematic analysis needs to be made of: i) the way in which water resource planning is carried out; and ii) the relationship between the planning process and the decision-making process which determines, in the first place, the concrete policies aimed at harmonizing supply and demand in respect of water-related services, and, in the second place, the way in which these policies operate in practice for those in the community (intra- and inter-generational) who are winners or losers in the solution of the inevitable conflicts of interest.

The analysis of experiences proposed here is regarded as a dynamic process which, form the outset, would assume the participation of the "actors" in the planning of water use and in the formulation and application of a policy in that sector. The first step would consist of a set of national monographs on the subject. The instruments for this stage would be horizontal co-operation through which a common methodology would be prepared with a group of local consultants from different countries in a short preparatory course. The local consultants, with the help of participants from all the national sectors and international specialists, would carry out the different studies.

The results of this work would be assessed halfway through the period, and, if it were necessary to complement it, the studies carried out for the said purpose would be directed vertically, that is, to the detailed study of specific aspects, or horizontally to obtain a greater geographical spread in the region.

5. The next steps

Interest in planning the management of water resources in Latin America and the Caribbean has certainly been on the increase. This has been mainly due to the increasing conflicts in respect of its development and control. Besides, the rise in the demand for water and the growing difficulties in satisfying it with the hydraulic works conventionally used to obtain and control more water resources —which are becoming more scarce and distant and therefore more costly— have aroused the interest of the countries in improving the operation and maintenance of their already available water systems and in the better management and conservation of their surface and underground catchment areas. This alternative course is only recently being undertaken in many places and hence its effect is still very slight. In addition to the foregoing there is the increasing pressure to give more consideration to the interests of the inhabitants of the regions from which the water is obtained —especially those of the inhabitants of the upper basins and the basins in which large hydroelectric power stations are installed to "export" energy— coupled with those of organizations concerned for the incorporation of greater environmental considerations.

All this, in the present context of a scarcity of economic resources to facilitate new and large investments and of social pressure to provide more equitable access to resource allocation, compels the governments to take effective measures for the regulation of water use. In practice it can be seen that they have been doing this and it is to be hoped that the work will continue and that the experience accumulated will be transmitted from one country to another. To achieve this it is suggested that as a first step a network of horizontal co-operation should be established between the government agencies responsible for the development and conservation of water resources in the region with emphasis on the role of water as an essential resource for development and human life.

Part Two

WATER-RELATED NATURAL HAZARDS *

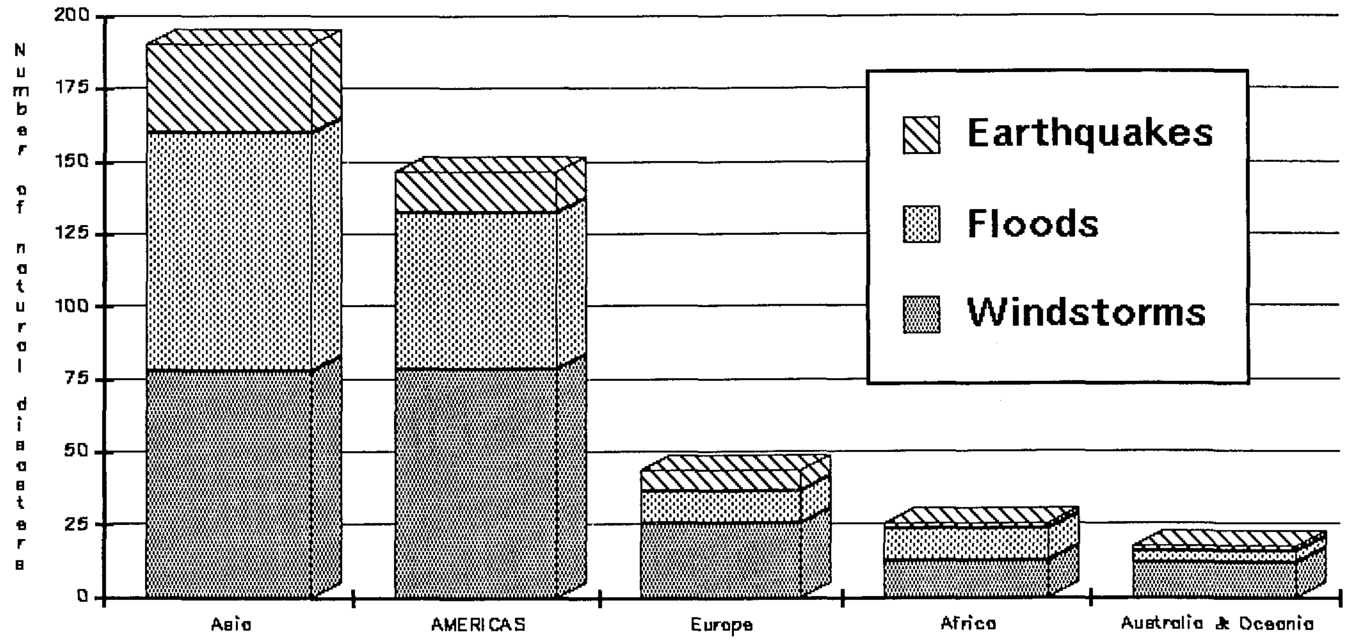
* This document is a revised version of document "The water resources of Latin America and the Caribbean: Water-Related Natural Hazards" published by ECLAC under the symbol LC/L.415/Rev.1, 28 December 1987.

Introduction

Natural hazards, understood as extreme natural events producing adverse impacts on man and the environment, and causing physical, ecological, economic and social damage, can be of geological or meteorological origin. Four phenomena —droughts, floods, windstorms and earthquakes— are estimated to be responsible for more than 90% of all loss of life and damage to man and the environment caused by natural hazards.[64] Most water-related natural hazards are of meteorological origin, but there are exceptions, for example, floods caused by a dam failure as a result of an earthquake. It has been estimated that, worldwide, windstorms and floods led to much greater economic losses between 1980 and 1985 than earthquakes although individually earthquakes are more destructive and cause greater loss of life.

It is probable that the region has been affected by water-related natural hazards during all the history of human settlement. The occurrence of drought can be traced back to, at least, 1052 in the Valley of Mexico and in Brazil references to droughts occur in the earliest reports of European colonists.[65] Contemporary, as can be seen from figure 11, the Americas suffer a greater number of hazard events than other regions of the world with the exception of Asia. Moreover, water-related hazards, windstorms and floods, are far more common than earthquakes. Not surprisingly, therefore, many areas of Latin America and the Caribbean are prone to natural hazards arising from extreme events related to water.

Figure 11
MAJOR WINDSTORMS, FLOODS AND EARTHQUAKES: OCCURRENCE BY REGION, 1980-1985



Source: Dusan Zupka, "Economic Impact of Disasters", UNDRO News, January/February 1988, p. 22.

A. THE GEOGRAPHICAL DISTRIBUTION OF NATURAL HAZARDS

The geographical distribution of the occurrence of natural hazards varies within Latin America and the Caribbean in relation to both climate and relief. In general, apart from droughts, which occur in almost all areas of both Central America and the Caribbean, and South America, the relative seriousness of the types of hazards which prevail is as follows:

a) The countries of South America are most frequently affected by floods and land or mudslides induced by floods. In these countries in recent years on average for every 100 persons killed, injured or missing as a result of floods and landslides there was only one killed, injured or missing as a consequence of a windstorm (see annex 1).

b) In Central America and the Caribbean the most severe natural hazards are windstorms (tropical depressions, storms and cyclones or hurricanes), which cause about 50% of all disaster deaths.[66] In these countries in recent years, on average for every 100 persons killed, injured or missing as a result of windstorms less than 19 people were killed, injured or missing as a consequence of floods or landslides (annex 1).

B. CHARACTERISTICS OF NATURAL HAZARDS

The damage caused by natural hazards depends on both their intensity (the speed of the wind, the intensity of the rainfall etc.) and their duration, as well as, the nature of the economic and social development in the affected area. Other things being equal, the impact of any natural hazard tends to be more damaging on smaller countries as the destruction from a single event may extend over the entire territory.

Different hazards, droughts, floods, windstorms etc., have different impacts on man and on the environment (table 9). In some cases, however, the impact of two hazards may be similar. For example, the consequences of windstorms and floods can be identical as flooding is a common companion of the storm surge.

Table 9

MATRIX OF MAIN ECONOMIC AND SOCIAL EFFECTS OF NATURAL HAZARDS

	Probability		
	Wind-storms	Floods	Droughts
I. Characteristics of natural hazards			
1. Larger affected area	VH	L	VH
2. Longer duration	L	L	VH
II. Damages			
1. Industry	VH	VH	L
2. Agriculture	VH	VH	VH
3. Infrastructure			
(a) transport	VH	VH	L
(b) water supply	VH	VH	H
(c) waste disposal	H	H	H
4. Population			
(a) hunger	H	H	VH
(b) contamination by biological and chemical agents	H	VH	L
(c) destruction of social infrastructure	VH	VH	L
III. Main damage-causing factors	surge of water and wind; torrential rain; see "Flood"	submer-gence; surge of water	aridity high tempera-ture

Source: This matrix was compiled party on the basis of material in "Salud ambiental con posterioridad a los desastres naturales", Publicación Científica No. 430, Pan American Health Organization, 1982.

Note : VH - probability is very high; H - probability is high; L - probability is low.

1. Droughts

a) *The nature of drought*

There is no quantitative definition of drought that is universally acceptable. In fact the definition of drought can vary according to the purpose for which the definition is required.[67] Drought is a relative phenomena and may be defined as an abnormal period during which stream flows are inadequate to supply established uses under a given water management system.[68] Drought differs from aridity which is a permanent state by its periodicity. The imbalance between water supply and water demand characteristic of drought can occur in both arid and humid areas. Drought is the most insidious of natural hazards in that it tends to develop slowly and can last for long periods even several years as in the northeast of Brazil.

The four main causes of drought are all operative in Latin America and the Caribbean:[69]

i) Widespread and persistent atmospheric subsidence, which results from the general circulation of the atmosphere. Such subsidence tends to be created in subtropical latitudes, the major affected areas include the northeast of Brazil, northern Chile, southern Peru and northern Mexico.

ii) Localized subsidence induced by mountain barriers or other physiographic features. The area affected in Latin America and the Caribbean is limited to Southern Argentina since the phenomenon occurs only in the middle latitudes.

iii) Absence of rain making disturbances, causing dry weather even in the areas of moist air. This phenomena gives rise to the long dry summer of Central Chile and is the cause of droughts that frequently affect the highlands of Peru.

iv) Absence of humid air streams. Some minor areas of South America —northeastern Argentina and neighbouring parts of Bolivia and Paraguay, for example— are quite remote from sources of humidity.

The four main types of drought, permanent, secular, seasonal and contingent, are found in Latin America and the Caribbean:[70]

i) The major regions of Latin America and the Caribbean that suffer from permanent drought are: Baja California and the north and northeast regions of Mexico; the Guajira region of Colombia; a broad coastal strip on the Pacific Ocean extending from latitude 4° south in northern Peru to approximately latitude 28° south in Chile, which includes the driest area in the world —the Atacama desert; a large area of southern South America, including part of the Bolivian plateau, an extensive tract of the Chaco (Bolivia, Paraguay and Argentina), and the northeast, central-west and extreme south areas of Argentina.

ii) Secular drought, in which a sequence of drought years alternate with years of adequate rainfall, occurs in tropical sub-humid regions. This type of drought is prevalent in the northeast of Brazil where it occurs with a five to seven year sequence. The most seriously affected area covers about 1.0 million km^2 and has a population of 26 million.[71] In this century alone sixteen years have been characterized by droughts.[72]

iii) Seasonal drought occurs mainly in semi-arid or sub-humid climates with a short wet season.

iv) Contingent drought is an infrequent water shortage which may occur in a part of the region.

b) *The impact of drought on man and the environment*

Droughts are frequent both in Latin America and the Caribbean: in recent years significant droughts have occurred in Bolivia, Brazil, Chile, Costa Rica, Cuba, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, and Peru among other countries.

Drought produces severe impacts on both man and the environment. Its effect slowly accumulates and has a tendency to persist for extended periods. The paramount environmental consequence of drought is desertification, although this is a complex process which is a result of several cumulative factors in addition to drought including salinization and poor soil management among others.[73] The area affected by desertification in South America is shown in table 10.

The more immediate consequences of drought include the following:

i) Famine and shortage of drinking water. For example, in 1985, as a result of the prolonged drought, water rationing was imposed in Havana, Cuba.[74] Severe drought which in 1986-1987 affected El Salvador has been reported to have caused food shortages leaving 40 000 rural families without food.[75] Despite all the measures taken to mitigate the impact of drought in the northeast of Brazil, more than 25 million people can still be affected.

ii) Disease from the use of contaminated water, death of cattle, lack of water for waste disposal, malnutrition, etc., also take their toll. For example, the 1982-1983 drought in Bolivia and Peru led to an increased incidence of gastrointestinal and other diseases in the population of affected areas.[76]

Table 10

AREA ALREADY AFFECTED AND LIKELY TO BE AFFECTED BY DESERTIFICATION IN SOUTH AMERICA

Degree of desertification hazard	Affected territory	
	km^2	%
Moderate	1 602 383	9.0
High	1 261 235	7.1
Very high	414 195	2.3
Extreme desert	200 492	1.1

Source: United Nations Conference on Desertification, A/CONF. 74/2, p. 9.

iii) Crop failure and the drying-up of pastures leads to the death of livestock, the decline of agricultural production and in related industrial production, and often the abandonment of land through migration. The 1982 dry spell in El Salvador was very severe and the soil water storage was not sufficient to meet crop demands. Some crops were lost entirely.[77] As a result of a damaging drought which affected agricultural production in the south of Honduras in the second half of 1986, as much as 80% of the grain harvest in the departments of Valle and Choluteca may have been lost.[78] In 1987 in the northeast of Brazil, a so called "green drought" led to the loss of 80% of the anticipated harvest.[79] The 1982-1983 drought in Bolivia, for its part, completely or partially destroyed the crops of some 1.6 million peasants and caused the death of many cattle.[80]

Decreased agricultural and related industrial activity due to severe droughts can lead to a noticeable increase in unemployment, particularly among the rural population.

iv) Increasingly, droughts affect not only agriculture but also the urban population, hydroelectric power generation and industries which use water in their production processes. For example, the 1977 drought in Mexico caused a reduction in hydro-electricity production.[81] In El Salvador, hydroelectric power production was sharply curtailed because of a drought described as the worst in thirty years and as a result electricity rationing was instituted.[82] Droughts also forced Guatemala and Panama to restrict electricity consumption.[83]

Droughts can adversely affect river transport. For example, in Colombia during periods of intense droughts the depth of certain waterways belonging to the Magdalena river basin drastically decreases hampering navigation.[84]

The detrimental effect of droughts may be aggravated through the lack of water for the dilution and transport of wastes. This is particularly important in the region since a considerable part of population has no access to a protected source of drinking water (14% of urban population and 55% of rural population)[85] and practically all wastes are discharged into the nearest water body without prior treatment.

v) Drought degrades and removes the vegetation cover, induces soil erosion, kills wildlife, destroys some land and water-based ecosystems, etc. It was estimated that during the 1982-1983 drought in Bolivia, 4.8 million hectares of pasture were destroyed by cattle and that some 40% of this area would not recover even under normal meteorological conditions.[86]

2. Windstorms

Windstorms are widespread in Latin America and the Caribbean, but the region which suffers most destruction from this hazard is the Caribbean and adjacent areas of Central America and Mexico. In most years this region suffers major economic damage and serious loss of life from tropical cyclones or hurricanes. The discussion of windstorms will concentrate, therefore, on the impact of tropical cyclones on the Caribbean.

a) *The nature of tropical cyclones*

Tropical cyclones are very intense cyclones, almost perfectly circular in form that develop over warm oceans. In their most extreme manifestation, as a hurricane, wind speeds exceed 118 kilometres per hour and in the region of maximum winds surrounding the eye the speed can reach 260 kilometres per hour. They are the most powerful wind systems found on the globe.[87] Even at lower intensities defined as tropical depressions or tropical storms, tropical cyclones may cause considerable damage.

In the Caribbean Sea tropical cyclones form in the southeast or in the Atlantic Ocean over the open sea when the collision of hot, moist air and of cool air provokes an updraft and subsequent condensation of moisture into rain. This process releases heat which funnels the air upwards. Due to the earth's rotation the rising column of air begins to spiral and a cyclone comes into existence. The cyclone moves from the open sea in the southeast of the Caribbean towards the northeast following a parabolic trajectory.

The average life span of a tropical cyclone is from six to nine days, but may vary from a few hours to several weeks. Cyclones move at a rate of 300 kilometres or more a day, often covering 2 000 to 3 000 kilometres in the course of their life. The average diameter is approximately 160 kilometres but it may extend up to 480 kilometres. This is why, when a tropical cyclone hits a Caribbean island or a small Central American country, devastation commonly extends over the entire territory and frequently affects not one but several States at the same time, as was the case with the hurricanes David and Frederick which struck the Dominican Republic, Dominica, Puerto Rico, Cuba, Haiti and other islands in 1979.

The hurricane season extends from June to November, on rare occasions, however, hurricanes have occurred in May and December. As a rule, about 100 tropical depressions are registered annually, but only about 10% reach storm strength and fewer than 6% reach hurricane strength.[88] On average, eight severe tropical storms or hurricanes sweep yearly over the Caribbean and adjacent areas of the Atlantic Ocean, as well as over the Pacific off Central America and Mexico. In recent years Barbados, Costa Rica, Cuba, Dominica, Dominican Republic, Grenada, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Saint Lucia as well as other countries were affected by tropical storms and/or hurricanes, several times.

Tropical cyclones are accompanied by torrential rains and high winds that can push walls of ocean water onto coastal areas. The volume of rainfall associated with individual storms varies, but amounts of as much as 500 millimeters or more are not uncommon; for example, in Honduras in 1982, 600 millimetres fell in three days, and in Nicaragua the rainfall from the same storm reached as much as 860 millimeters; and in Cuba, also in 1982, the total rainfall from the hurricane Alberto over nine days reached 800 millimetres and a new local record of 2.4 millimetres of rain per minute was established.[89] This compares with average annual precipitation in Central America and Cuba of some 2 000 to 2 200 millimetres.

b) *The impact of tropical cyclones on man and the environment*

The heat energy released per day by an average cyclone can be compared to that released from about 400 hydrogen bombs of 20 megatons each.[90] Hurricane "Hazel" in October, 1954 was dissipating kinetic energy at rate equivalent to one-quarter of that required to maintain the circulation of the atmosphere north of latitude 30° N.[91] It is hardly surprising, therefore, that when a tropical cyclone hits a heavily populated area damages are likely to be enormous.

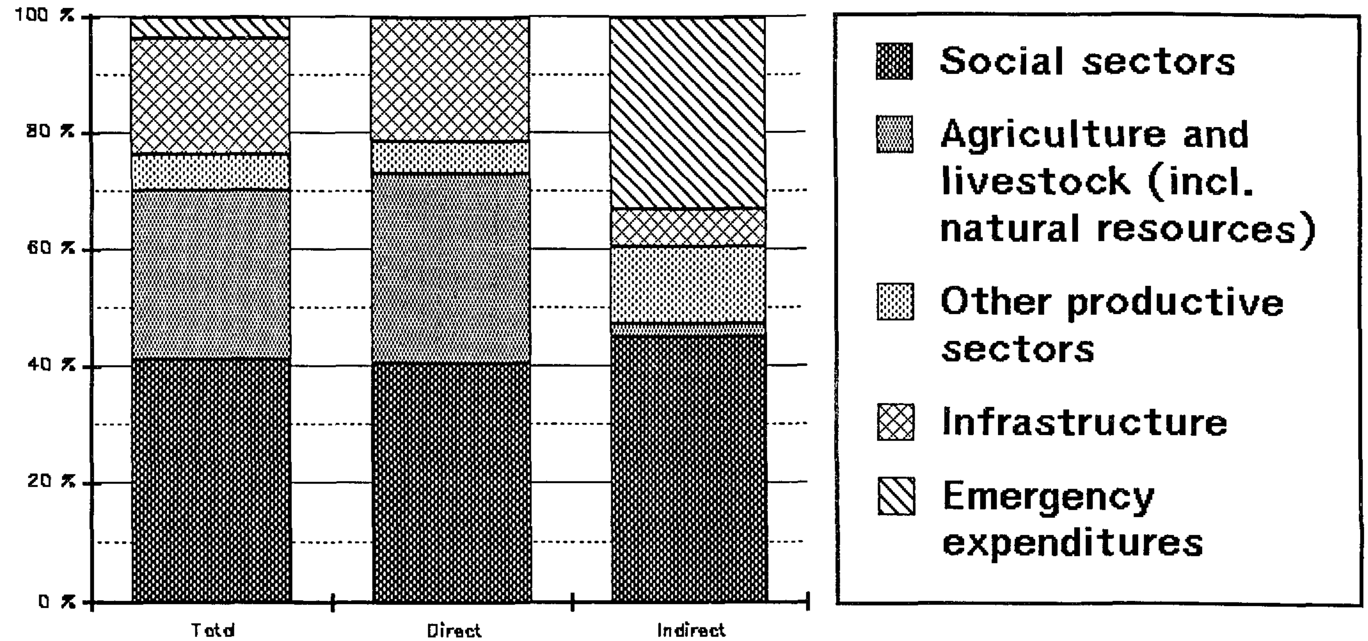
The destruction caused by tropical cyclones are due to three factors: the high winds, the storm surge and the ensuing floods caused by the associated torrential rain. The most destructive of the three is the rainstorm-surge combination in coastal areas, which gives rise to catastrophic flooding. The storm surge is a rapid rise in the sea level produced by the hurricane winds and falling barometric pressure.

Some of the biggest tropical cyclones that have struck Latin American and Caribbean countries in recent years include: hurricane "Fifi" (1974) which caused an estimated 6 000 to 8 000 deaths in Honduras;[92] hurricane "David" (1979) devastated most of the island of Dominica and large parts of the Dominican Republic, killing over 1 400 people, injuring 6 000, leaving more than 260 000 homeless and causing damage estimated at US$830 million; in 1980 a hurricane ripped through Saint Lucia, southwestern Haiti and northern Jamaica, leaving 250 dead, 205 000 homeless, 525 000 deprived of their normal source of food and US$530 million damage to housing, infrastructure and agriculture;[93] and hurricane "Kate" (1985) caused total damages estimated at US$1 087 million and forced the evacuation of some 715 000 people in Cuba.[94] Between 1960 and 1981 Mexico and Haiti were the countries most affected by hurricanes, the first by 14 and the second by six, resulting 1 560 and 5 800 deaths, respectively.[95]

More recently, in September 1988, hurricane "Gilbert" affected several Central American and Caribbean countries, including Cuba, Dominican Republic, Jamaica, Haiti, and Mexico. In Jamaica, "Gilbert" caused 45 deaths, forced evacuation of approximately 1 million persons and left close to US$1 000 million in damages.[96] A month later, in October 1988, hurricane "Joan" passed over Nicaragua and caused 148 deaths and about US$840 million in damages. Distribution of these losses among different social and economic sectors is shown in figure 12.[97]

Tropical cyclones not only cause human deaths and injuries and destroy property, but also strip cultivated land in the coastal area of its vegetation cover, render the land sterile by salinity and

Figure 12
NICARAGUA: DAMAGE CAUSED BY HURRICANE JOAN, 1988



Source: Damage caused by hurricane Joan in Nicaragua. Its effects on economic development and living conditions, and requirements for rehabilitation and reconstruction, LC/G.1544 2 December 1988, p. 28.

subject it to soil erosion. For example, when in June 1982 Cuba was affected by hurricane "Alberto" and the tropical storm that followed it, an estimated 137 000 hectares of cultivated fields were totally lost or seriously damaged.[98]

The storm surge caused by cyclones can erode up to 9-15 metres of beach within an hour. Twelve hours of pounding by such waves is estimated to be equal to a century of normal wave action. This is likely to represent a particular concern for Caribbean countries since many of them suffer from coastal erosion. For example, both hurricanes "David" (1979) and "Klaus" (1984) were reported to have caused coastal erosion in Dominica.[99]

Apart from the immediate damage, the long-term consequences of tropical cyclones may also be serious. Large expanses of stagnant water and swamps can be left after a cyclone, and these not only impede reconstruction but also offer breeding grounds for vectors of debilitating diseases such as dengue fever and malaria. For example, in Cuba following the 1982 tropical storm a dengue fever epidemics was feared because ideal breeding grounds for the *Aedes Aegypti* mosquito had been created in the large expanses of stagnant water left behind as the floods receded. However, this particular epidemics was avoided partly with the help of applications of abate-malathion insecticide.[100] Adverse health consequences may be aggravated by the destruction of social infrastructure, housing, water supply and sewerage systems and health facilities. In Dominica, the passage of Hurricane David left 78% of the population homeless and destroyed almost the entire medical infrastructure.[101] More recently, hurricane "Joan" left similar damage in its wake around Bluefields, Nicaragua. It was estimated that the total damage to the housing sector was equivalent to US$296 000 000.[102]

Nevertheless, tropical cyclones may also have certain beneficial effects:

i) They bring increased rainfall, because cyclones lift and evaporate sea water and deposit it as salt free rain.

ii) Improved fishing results from the upwelling of nutrient rich water along or near the storm track. Phytoplankton mass at the surface before and after a severe hurricane in the Gulf of Mexico has been found to have doubled. In other areas large increases have been observed in the lobster population after rough seas and high tides due to hurricanes.[103]

3. Floods

a) *The nature of floods*

The most common damaging floods in Latin America and the Caribbean are caused by the overflowing of rivers and other inland waters, although sea floods due to tropical cyclones, earthquakes and tsunami on occasion cause severe destruction.

The common causes of flooding to be found in Latin America and the Caribbean are:

i) The incidence of heavy rainfall, which is the most widespread, since the majority of rivers are entirely rainfed. Heavy rainfall frequently also induces land or mudslides further aggravating the problems due to flooding.

ii) The occurrence of a strong and protracted snowmelt is a smaller problem for the region as it is only south of latitude 28° S that the upper basins of the rivers rising in the Andean cordillera receive a substantial quantity of water from glaciers and snowmelt.[104]

iii) Channel obstructions can cause a flood or exacerbate one which already exists. Common obstructions are the presence of weirs, bridge piers, floating debris, land slides or, at higher elevations, ice jams. In May 1960, a huge landslide, 27 metres high and 1 500 metres wide, dammed the Río San Pedro below Lake Riñihue, Chile, raising its level. A catastrophe was only prevented by artificial breaching of the "dam". The Santo River in Peru was dammed by a large rotational slip in May 1970.[105] In 1985, in the province of Mendoza, Argentina, the Grande del Nevado glacier crossed the river Plomo, damming the river and creating a lake of considerable volume which posed a serious flood threat to the valley.[106]

iv) Other factors, including tidal surges, wind set-ups in estuaries or downstream river surges caused by a dam failure, mud flow or other similar events can cause flooding or aggravate already existing floods. Accidents arising from failure of hydraulic structures tend to be particularly grave. One such accident took place in April 1981, in Brazil, when during intense rainfall failure of six small upstream dams caused the Mãe D'Agua Dam to fail. This rose the level of the Santa Cruz Reservoir overtopping the dam by more than 1 metre. As a result, approximately 12 million cubic meters of water were released, flooding Santa Cruz, destroying many buildings and leaving about 5 000 people homeless.[107]

Floods can also result from a combination of events. For example, in June 1986, heavy rains and snowmelt caused serious flooding in Central Chile, destroying more than 1 000 homes and causing losses estimated at US$22.3 million.[108]

The character of flooding is generally, but not exclusively, determined by the size of the catchment tributary. The Paraguay River basin is so vast that periods of flood tend to be very long. In the last 25 years, in no major flood in the river has the period between flood crest and flood peak been less than 15 days at Santa Fe, Argentina, and in most floods it has been closer to 30 days.

In contrast, short rivers, such as those of the Pacific watershed, are more commonly associated with "flash floods". Such floods are particularly dangerous because very little time elapses between the start of the flood and the peak discharge and quite often between the onset of the storm and the arrival of the flood wave. Such flooding is not, however, limited to the Pacific coast, in January 1983, flash floods caused by torrential rains claimed 51 lives and left 2 000 people homeless around the town of Belo Horizonte in the southeast of Brazil.[109]

b) *The impact of floods on man and the environment*

Floods are very frequent in Latin America and the Caribbean. Since 1979 floods have been reported in Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Paraguay, Peru, Venezuela as well as other countries. The number of significant flood events and the number of deaths have increased in recent years (see figures 13 and 14). Of the twenty countries in the world with the highest number of deaths from floods between 1977 and 1984, seven are Latin American.[110]

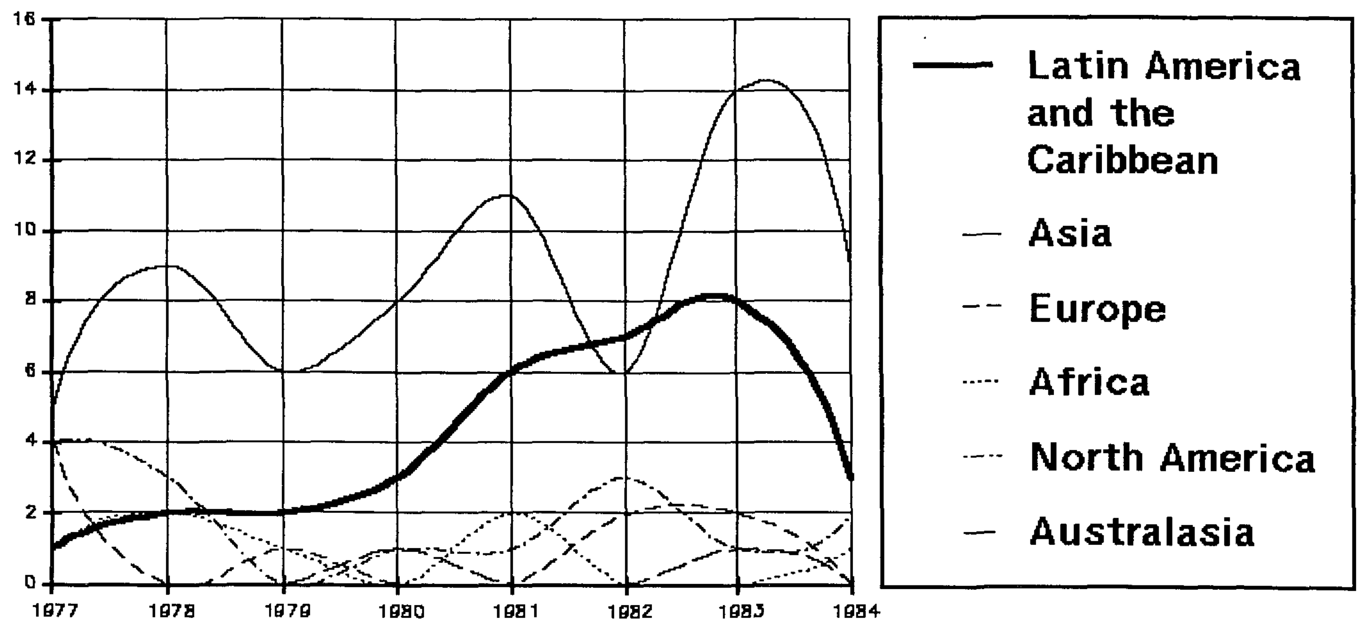
In areas of high density of human activity, particularly urban areas, and also in regions of intensive agriculture where crops cannot withstand prolonged submergence, damage from floods can be catastrophic. In several Latin American countries a significant part of the population (see table 11), and hence of agriculture and industry, are located in areas exposed to catastrophic floods.

The main impact of floods on economic and social development includes the following:

i) Human deaths and injuries caused either directly by flooding or indirectly, through flood-related land or mudslides, destruction of buildings, etc. The number of deaths and injuries may vary considerably according to density of population, the pattern of economic and social infrastructure in the affected area, as well as the quality of the warning system, the speed and intensity of flooding

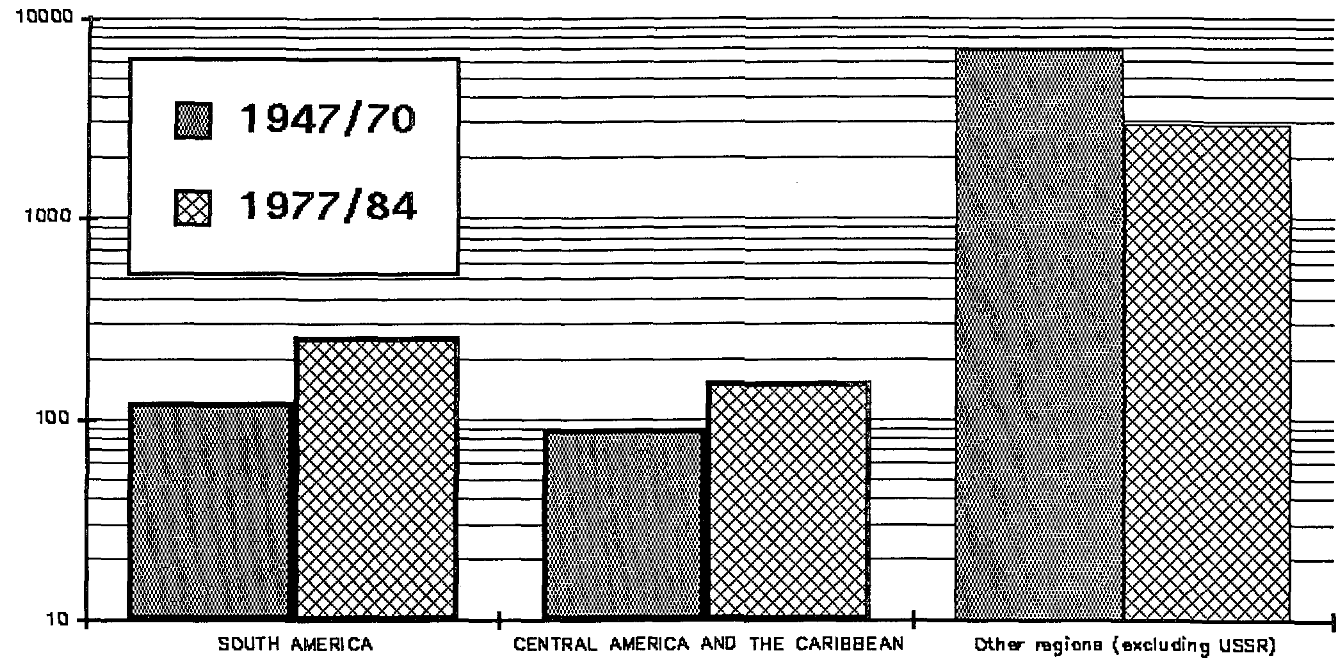
Figure 13

NUMBER OF SIGNIFICANT FLOOD EVENTS INVOLVING LOSS OF LIFE BY CONTINENTS, 1977-1984



Source: A.A. Khan, Improved efficiency in the management of natural hazards: floods, MDPFU/SYMP/7, November 1986, p. 2.

Figure 14
AVERAGE ANNUAL LOSS OF LIFE IN FLOODS



Source: A.A. Khan, Improved efficiency in the management of natural hazards: floods, MDPFU/SYMP/7, November 1986, p. 17.

Table 11

LATIN AMERICA AND THE CARIBBEAN, SELECTED COUNTRIES, APPROXIMATE PERCENTAGE OF POPULATION LIVING IN AREAS EXPOSED TO CATASTROPHIC FLOODS

Country	Percentage of Population
Argentina	8 - 10
Bolivia	7
Brazil	15
Costa Rica	3
Guatemala	15

Source : K. Szestay, "River Basin Development and Water Management", Water Quality Bulletin, Vol. 7, No. 4, October 1982, p. 157.

and other factors. Floods have caused many deaths in Latin America and the Caribbean in recent years for example: in El Salvador (September 1982) —600 dead—, in Guatemala (September 1982) —600 dead—, in Honduras (September 1982) —200 dead—, in Ecuador (1982-1983) —300 dead—, in Peru (1982-1983) —233 dead—, in Colombia (1984) —152 dead—, and in Brazil (January, March, 1985) —200 dead.[111] There are, however, no reliable statistics on a region-wide basis. Estimates suggest that there were, at least, 4 700 deaths from flooding between 1960 and 1981 and 2 700 between 1977 and 1984 (table 12).

ii) Flooding leads to epidemics of water-borne and water-related diseases. The floods in Bolivia, Ecuador and Peru in 1982-1983 were the cause of outbreaks of malaria, various gastrointestinal and other diseases in several areas.[112] In February 1988, an outbreak of the parasitic disease leptospirosis, carried by contaminated water, claimed 18 lives and left 412 ill in the state of Río de Janeiro, Brazil.[113]

iii) The destruction of industrial and agricultural buildings, social infrastructure, manufactured products, the contamination and disruption of agricultural production and other damages.

Table 12

ESTIMATES OF DEATHS FROM FLOODS IN SELECTED LATIN AMERICAN COUNTRIES

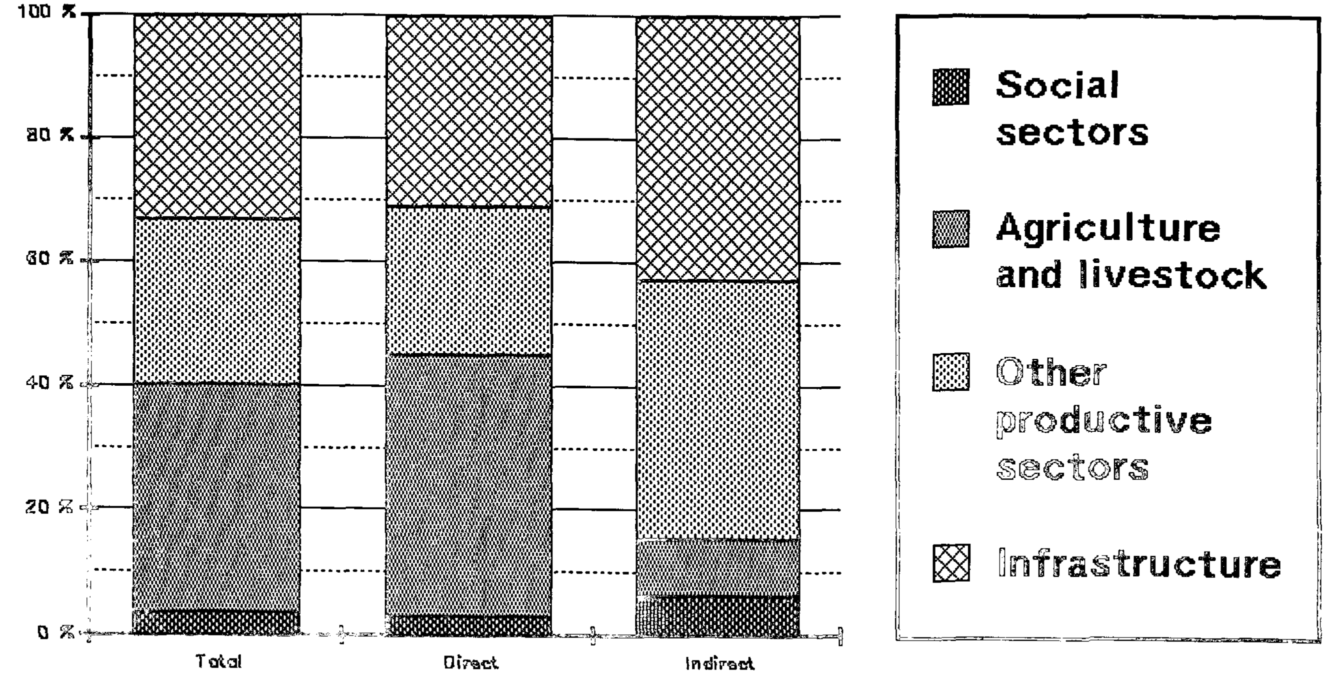
	World Resources Institute 1960 - 1981		Khan 01.01.1977 - 31.12.1984	
Country	Number of floods	Number of deaths	Number of deaths	Percentage of global loss of lives in floods
Argentina	9	200	n.a.	n.a.
Bolivia	13	160	276	1.1%
Brazil	28	2 850	288	1.2%
Colombia	10	600	517	2.1%
Costa Rica	8	30	n.a.	n.a.
Ecuador	7	20	330	1.3%
El Salvador	n.a.	n.a.	700	2.9%
Mexico	11	370	180	0.8%
Panama	6	100	n.a.	n.a.
Peru	9	350	435	1.8%
Total	101	4 680	2 726	11.2%

Source : League of Red Cross and Red Crescent Societies; U.S. Office of Foreign Disaster Assistance, cited from *World Resources 1986*, World Resources Institute, International Institute for Environment and Development, p. 306; and A.A. Khan "Flood management: alternative measures for improvement", *Water Resources Journal*, June 1987, p. 60.
n.a. = information not available.

The total economic cost of floods can be enormous and spread throughout the whole economy. Estimates have been made of the distribution of the more than US$600 million losses caused by the 1982-1983 flood among the different social and economic sectors in Ecuador (figure 15).[114] The 1982 floods in Nicaragua caused damages

Figure 15

ECUADOR: DAMAGES CAUSED BY FLOODS, 1982-1983



Source: The natural disasters of 1982–1983 in Bolivia, Ecuador and Peru, E/CEPAL/G.1274 26 January 1984, p. 11.

estimated to be equivalent to 20% of the 1981 Gross National Product.[115] The floods which affected the Pampa region, particularly the Province of Buenos Aires, Argentina, during the last quarter of 1985 and intermittently through March 1986, caused losses to crops, farm infrastructure and services estimated at more than US$1.3 *thousand million*.[116]

Particularly grave environmental consequences tend to be caused by flash river flooding, extreme sea floods or flooding in normally arid zones. In addition, in many countries of the region the destructive impact of floods is aggravated by peculiarities of relief and soil characteristics, and many are accompanied by land or mudslides which not only produce additional damage but also impede rescue operations and reconstruction. It has been estimated that in recent years at least 20% of all floods in Latin America and the Caribbean were accompanied by landslides (see annex 1).

Flooding can be a beneficial process, particularly for some agricultural or pastoral uses. An example is afforded by the Apure flood plains around San Fernando, Venezuela, where major efforts have been made to retain floods so as to permit a longer growing season for natural pastures to support livestock production.

4. Land and mudslides

Land and mudslides are generated either by flood causing events, such as torrential rains or strong and protracted snowmelt, or by seismic and volcanic activity. The presence of populated areas in zones affected by floods, deforestation and other factors increase both the risk of landslides and the damage caused.

Mudflows associated with the eruption of volcanoes with large crater lakes for example, the Saint Vincent Soufriere Volcano on St. Vincent in the West Indies, or with massive accumulation of snow on their slopes are far more destructive than flood associated slides because of their high speed and large volume. "Secondary" mudflows can develop on volcanoes when strong rain falls on slopes covered by unconsolidated volcanic ash and may represent a hazard during periods of heavy rain both during and several years after an eruption.[117]

The most severe volcanic mudflow of recent years was provoked by the eruption of the Nevado del Ruiz Volcano in the central Cordillera of the Colombian Andes on 13 November 1985. As a result of the eruption of red-hot pumice blocks, the snow and ice at the peak melted, provoking a mudslide or *lahar* consisting of mixture of water, pumice and soil. This slide descended along the channels of the Azufrado and the Lagunilla rivers which were already swollen by heavy rains, caused the collapse of a natural dam and the ensuing flood swept away the town of Armero, located 45 kilometres from the crater.[118] This mudslide is estimated to have killed 23 000 people, 90% of the population of Armero, injured 5 000 and displaced thousands more. In total, some 200 000 people were affected by the disaster.[119] Fortunately, such events are rare, although in 1845 the eruption of the same volcano caused an avalanche and giant mudflows which killed over 1 000 people.[120]

Although land and mudslides induced by flood causing factors are not usually so devastating as volcanic ones, they are much more widespread and frequent. In recent years, such slides have been reported to have occurred in Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, and Venezuela. Landslides are particularly destructive in urban areas. A mudflow in the northwestern area of San Salvador killed 350 people in 1982 and similar disasters struck Petropolis, Brazil and Caracas in the last two years.

Landslides can induce large waves where steep slopes abut the sea, lakes, rivers or reservoirs. Landslide caused waves on Lake Rupanco, Chile in 1960 were reported to have caused severe damage to settlements and fields and even some loss of life.[121]

5. Tsunamis

Tsunamis are tidal waves produced by the sudden displacement of a large column of water usually due to either an earthquake or a volcanic eruption below or at sea level. Both earthquakes and volcanic eruptions have been the cause of tsunamis in Latin America and the Caribbean. In the eastern Caribbean, four submarine volcanoes have been reported active in historic times, and there may be others.[122] The west coast of South and Central America faces the Pacific Ocean which, as a result of high volcanic and seismic activity, is the most frequent scene of tsunamis —on average 2-3 tsunamis have been observed annually in recent decades, however, the majority did not result in damage.[123]

Tsunamis spread in all directions from their point of origin and may reach a speed of 1 000 kilometres per hour in the deep ocean. The giant destructive capacity of tsunami is derived from the fact that the height of the waves increases considerably in shallow coastal areas reaching in extreme cases as much as 20 or 30 metres.[124] The most destructive tsunamis recorded occurred from several decades to more than a century ago. The worst tsunami known to have hit the coast of Peru was triggered by the 1746 earthquake in Lima. It swept over the port of Callao (out of a population of 5 000 only 200 survived) and up to 1.5 kilometres inland. In August 1868, a tsunami affected the area adjacent to the city of Arica, Chile.[125] In 1906 a tsunami caused 400 dead and destroyed 500 houses in the town of Tumaco in Colombia.[126] In May 1960, a tsunami caused several deaths in Chile.[127]

C. MEASURES FOR THE MITIGATION OF NATURAL DISASTERS

In recent decades, the governments of the countries of Latin America and the Caribbean have recognized the need to take measures to reduce the social and economic consequences of natural hazards. These efforts have, at least, ameliorated the extent of the damage caused by natural hazards. Such measures, in themselves are costly, but represent only a small fraction of the economic losses caused through natural disasters.

Measures for the mitigation of natural disasters can be classified as preventive, planning and preparedness measures which can be further divided into two broad groups:

a) Structural or engineering.

b) Non-structural measures.

1. Structural measures

A number of structural concepts have been evolved as means of preventing or reducing the damage caused by natural hazards, including:[128]

a) Confinement (flood walls, levees, etc.).

b) Detention (landslide retaining walls, flood control dams, etc.).

c) Dissipation (wind breaks, sea walls, breakwaters, etc.).

d) Diversion (avalanche diversion sheds, flood by-pass channels, diversion of mudflows, etc.).

Structural measures of flood-control have been adopted to a certain extent in many river basins in Latin America and the Caribbean. The most widely diffused measure is the construction of dykes or containing walls to control the river course and prevent overbank flooding: for example, many of the Pacific coast rivers of Peru have been dyked; in Brazil levees, floodwalls, sluicing canals and other works are commonly used to protect towns;[129] the lower course of the River Guayas in Ecuador was dyked in 1976; and, the containing walls of the River Mapocho in Santiago, Chile, were extended into the upper suburbs after the 1982 flood.[130] In Venezuela, flood control structures have been constructed for the protection of the towns of Caracas, Maracaibo, Charallave, Morón, and also on the rivers of Apure, Arauca, as well as in other areas.[131]

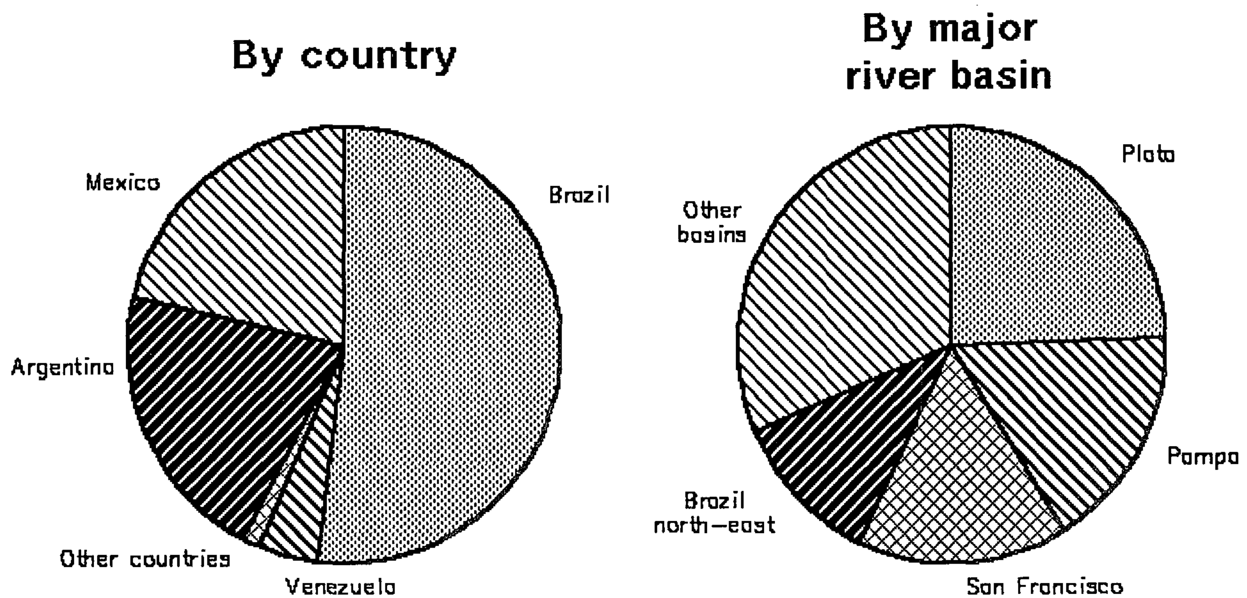
In 1984, in Latin American and Caribbean countries there were some 257 large dams providing a total reservoir storage capacity of 215 000 million cubic metres destined wholly or in part for flood control. This represents 19% of all dams in the region and 33% of their storage capacity. Most frequently, flood-control storage is provided as part of multi-purpose dams built for irrigation, hydro-electricity production or drinking water supply, as well as flood control. Dams constructed exclusively for flood control are relatively rare. The distribution of flood-control dams by countries and major river basin is shown in figure 16.

Several structural measures may be used for flood-control in different parts of a river basin, for example, reservoirs in the upper basin and containing walls in the lower.

To reduce the impact of droughts, efforts have been concentrated on the expansion of irrigation through construction of storage reservoirs, groundwater wells and the related water distribution systems. The area under irrigation has increased from 8 403 000 hectares in 1961-1965 to 14 707 000 hectares in 1985. The increase is particularly notable in the Caribbean where the area under irrigation has more than doubled. In Latin America and the Caribbean the area under irrigation has been growing at a higher rate than in the world as a whole.[132] Reservoir storage capacity behind large dams for irrigation increased considerably in the last two decades, at an average annual rate of 6.3% between 1966 and 1985.[133] The development of irrigation in drought-prone areas is likely to continue in the future, for example, a five year Irrigation Programme for the Northeast was enacted in Brazil in 1986. It is proposed under this programme to increase the area under public and private irrigation in the northeast by 1 000 000 hectares by 1990.

Apart from traditional irrigation systems based on reservoirs and wells, other methods also have been applied to counteract drought. Not surprisingly, this is particular to the Northeast of Brazil. For example, pot-and-capsule irrigation systems; subterranean sand-trap dams; so called "salvation" dams, small reservoir systems designed for a sloping area leading to a cultivation area at the bottom, manually filled porous earthen pots, relatively inexpensive drip and sprinkler irrigation systems have been tried among others.[134] In a number of countries experiments have been made in tapping unconventional water sources. For example, in Argentina, Bolivia, Brazil, Chile, Mexico and Peru investigations are being made into the direct

Figure 16
LATIN AMERICA AND THE CARIBBEAN: STORAGE CAPACITY BEHIND LARGE DAMS BUILT FOR FLOOD-CONTROL PURPOSES



Source: International Commission on Large Dams (ICOLD).

collection and storage of rain water and projects to capture fog humidity are under way in Chile, Peru and Ecuador.[135]

Attention is being paid to the more efficient use of water in general not only as a measure to reduce the economic and social costs of drought. One aspect of this concern is the growing consideration of the reuse of water. Undoubtedly, the most notable example is afforded by Mexico where in the Federal District (Mexico City) some 155 500 m^3 of water is reused daily, equivalent to 4% of total water demand. The reused wastewater is mainly used to supply recreational lakes and for the irrigation of public parks. Present plans call for 17% of the wastewater of the District to be reused by the year 2000 equivalent to some 12% of projected water demands.[136] The Mexico scheme is considered to be the biggest use of raw sewage for irrigation in the world. Currently some 82 000 hectares are irrigated by this means around the capital and there exist plans to convert to sewage-fed irrigation a further 128 000 hectares of land elsewhere in Mexico.[137] In Peru, at San Juan de Miraflores, near Lima, a project was begun in 1961 to investigate the productive reuse of sewage wastewater for irrigation; currently 500 hectares are being irrigated, with 1 300 more planned for the future.[138]

There are few structural measures that can be used to mitigate the impact of tropical cyclones and tsunamis. However, certain structural protection can be provided against the storm surge and flooding. For example, the most important port of the Dominican Republic —Haina— is protected from cyclone induced storms by breakwaters erected in 1951.[139]

Structural measures are usually highly capital-intensive, partly because they must be designed to withstand the effect of some expected maximum event. Generally, investments in protective structures are worthwhile if the expected stream of benefits over the life of the structure exceed the cost. For example, it has been estimated that losses caused by floods on the river Mapocho, Chile are approximately 20 times higher than the cost of investment required to protect the urban area from them.[140] At the same time, however, in considering alternatives it should be taken into account that the ability to protect from extreme events is limited so that in economic terms the construction of the required works may not be justified.

2. Non-structural measures

The range of non-structural measures for disaster prevention, planning and preparedness is very large. It is possible to classify those most commonly applied in Latin America and the Caribbean into the following manner:

i) Prevention measures including warning systems, land-use controls, building regulations and disaster-related education and training;

ii) Planning to reduce the disaster-related impacts of natural hazards, such as vulnerability analysis of settlements and infrastructure and consideration of the impact of hazard-related disasters on long-term development decisions;

iii) Preparedness in the form of the adoption of measures to organize and facilitate emergency relief and rescue operations including regional co-operation for disaster mitigation.

a) *Warning systems*

Warning systems are indispensable for effective action to mitigate disasters caused by natural hazards. Warning systems are most effective with hazards that can be detected at an early stage in their existence and whose subsequent history can be monitored with a reasonable degree of accuracy. This is the case with some floods and tropical cyclones, when the expected arrival time and force can be accurately predicted within 24 hours of their appearance. It is common, however, for warning systems and other hydrological and meteorological networks to suffer severe damage during disasters. For example, as a direct result of hurricane Gilbert, the hydro-meteorological network and the radar tracking stations were destroyed in Jamaica.[141] Warning systems are particularly important for tsunamis, as there are no known means of prevention and little possibility for structural protection.

Forecasting, prediction and warning measures in Latin America and the Caribbean are usually undertaken by national meteorological networks and civil defence organizations. Some countries have installed fairly sophisticated warning and forecasting systems, for example, real time flood forecasting systems.[142] Examples of national forecasting and warning systems are afforded by the System of Flood Alert for the Federal Capital (Argentina) and the Pilot System of Flood and Drought Alert for the river Guaire (Venezuela).[143] In Brazil, a National System of Warning against Floods is in operation, initially, in those river basins with the most serious flood problems, such as the Guaíba, Uruguay, Itajaí, Iguaçu, Ribeira do Iguape, Paraíba do Sul, São Francisco and Capibaribe. There is also a telemetric flood control network located in the Pantanal Region of Mato Grosso, in the Paraguay river basin.[144]

Regional forecasting and warning measures are particularly important in the Caribbean and Central America. The Hurricane Committee, under the auspices of the World Meteorological Organization, co-ordinates the planning and review of national and regional hurricane warning activities and early hurricane warning and flood forecasting is co-ordinated in close co-operation with the United States' National Hurricane Centre in Miami. In South America co-ordination and co-operation in flood forecasting is maintained mainly in the River Plate basin, where Operational Hydrological Alert Centers have been set up in Buenos Aires, Asunción and Brasilia, to provide the information needed for forecasting floods on the rivers Paraná, Paraguay and Uruguay.

In the case of drought forecasting, apart from forecasts prepared by national meteorological services, the United States Agency for International Development (USAID) provides bi-weekly drought and crop condition assessments throughout Central and South America and the Caribbean Basin in co-operation with the National Oceanic and Atmospheric Administration (NOAA).[145]

A forecasting system for tsunamis is maintained in the Pacific. In 1965, the United States, in co-operation with UNESCO's Intergovernmental Oceanographic Commission (IOC), expanded its existing Tsunami Warning Center in Honolulu to become the headquarters of the International Pacific Tsunami Warning System. At present, the Pacific Tsunami Warning Center (PTWC) at Ewa Beach near Honolulu is operated by the U.S. National Weather Service. Among South and Central American countries, Chile, Colombia, Ecuador, Guatemala, Mexico and Peru are members of the International Co-ordination Group for the Tsunami Warning System in the Pacific. Since 1986, Chile has operated a national system for local tsunami warning.[146]

b) *Emergency measures*

The emergency measures include the preparation of emergency plans, construction of Disaster Centres (stocked with food, tents, equipment, medical supplies including vaccines, etc.), the establishment of disaster administrations, the development of emergency legislation, the preparation of priority lists of water users, the evacuation of population, movable goods and livestock, the development of emergency communication systems, etc. (The list of national emergency plans and disaster legislation is given in annex 2.)

In Latin America and the Caribbean emergency services are usually undertaken by civil defence organizations charged with responsibility for the response to all disasters regardless of their origin (annex 3). Specialized organizations that respond to a particular natural hazard have, however, a long history in the region. For example in Brazil, the first institution to counter drought, forerunner of the Superintendencia do Desenvolvimento do Nordeste (SUDENE), was established during the drought of 1903 although special drought commissions had existed since 1856, such as those in the River Plate basin in Paraguay and Argentina. At the same time, they acquire particular importance when they are the only measures available for reducing the impact of natural disasters and also in the case of rapidly developing disasters such as flash floods, tsunamis, tropical cyclones and land or mudslides. For example, the casualties from the hurricane Albert that struck Cuba in June 1982 were kept low by the speed and efficiency of the emergency operations. In 1985 when hurricane Kate, the worst to hit Cuba since the beginning of the century, only three lives were lost due to prompt action by the defence committees in organizing the evacuation of some 715 000 people.[147] Similarly, effective mobilization reduced the deaths and costs arising from the 1982 floods in Nicaragua.[148] Hurricanes, due to their tremendous destructive powers, may still cause large numbers of deaths even when successful emergency measures are taken.[149]

In the case of drought, measures related to regulating, rationing or reallocating available water supplies acquire particular importance. Therefore, in many countries, the public authorities reserve the right within irrigation districts to control the use of water rationing and establish systems for times of scarcity. In some countries specialized institutions like Brazil's have not been created, however, and responsibility for responding to the hazard in the short-run lies with the Water Departments, for example in Chile and Peru, and in the long-term with the institutions responsible for irrigation. One of the systems in use, for example, in the province of Mendoza in Argentina, relies on *pro rata* cutbacks when dealing with the same category of water uses. Proportional reductions in water allotments mean that the effects of water scarcity are equitably distributed among all water users.[150]

c) *Land-use controls*

The restriction of human settlements to areas of lower risk from natural hazards is known to offer enormous advantages, and in distinction from other non-structural measures, it is of high effectiveness in reducing property loss and economic disruption. On the whole, in Latin America and the Caribbean, land use planning measures are applied only in isolated cases within urban areas, although their use seems to be growing. For example, the activities of the Pan-Caribbean Disaster Preparedness and Prevention Project (PCDPPP) are directed towards supporting the efforts of the Caribbean countries to determine areas at high risk from tropical cyclones, floods and other natural disasters.[151] In December 1987, the PCDPPP, in co-operation with the University of the West Indies and the Office of Disaster Preparedness in Jamaica, sponsored a regional meeting of experts on hazard mapping.[152]

In Jamaica, an analysis of spatial variations in the occurrence of natural hazards has been made, and in other Caribbean islands disaster-controllable areas have been identified to improve protection systems, most notably perhaps in Cuba, which has a national disaster plan prepared by the Office of Civil Defence. The adoption of land use regulation as a flood damage reduction measure has been proposed in Argentina.

Land use planning and control is not only applied in the narrower sense of the restriction of certain uses in known high risk areas, but in the wider sense of attempting to establish new less risk-prone uses. One example of such a policy is afforded by the Atacama desert in northern Chile, where 18 000 hectares of Prospis tamarugo and algarroba (mesquite), which tap moisture from the atmosphere, have been planted to serve as cattle fodder.[153] In the northeast of Brazil industrial development is being stimulated with the aim of reducing the heavy dependence of the region on drought sensitive agriculture.

d) *Building regulations*

The prevention of building collapse and damage substantially reduces human death and suffering, limits property losses and supports post disaster emergency activities. Building regulations are an important means of controlling losses in the case of floods, tropical cyclones and other natural hazards which imply added loads for the building structure. It should be noted, however, that building regulations that can prevent damage from earthquakes and those designed to protect against tropical cyclones or floods do not necessarily coincide.

The incorporation of standards to withstand hazard induced stress into building regulations is usually considered to augment construction costs, but experience in the region shows that simple precautions can be effective. For example, such simple preventive measures as anchoring roofs securely to buildings or the provision of strong shutters for glass windows can considerably reduce damage from tropical cyclones.[154]

The use of building regulations for mitigation of natural disasters seems to be growing in the region, most notably perhaps in the Caribbean where the adoption of building techniques and codes that can reduce damage to buildings from tropical cyclones and other natural disasters is promoted by the PCDPPP.[155] In 1982 the Caribbean Community Secretariat, with assistance from various other organizations, embarked on the development of a Caribbean Uniform Building Code which, it is believed, could be the one single action contributing most over the next decade to reduce damages from tropical cyclones to buildings in the subregion.[156]

Building or construction standards and regulations are equally important for disaster mitigation structures, themselves, since the failure of these during a natural disaster can substantially increase damage.

3. Regional co-operation

There has been a considerable development in recent years in regional co-operation both in response to natural disasters and in measures for disaster prevention and preparedness. Such co-operation is achieved both through the United Nations and Inter-American systems and through specialized institutions.

Apart from co-operation in the operations of warning systems already mentioned earlier in the text, one example of co-operative activities is provided in the field of education and training. The training of specialized personnel is provided by the Pan American Health Organization (PAHO) and the Centro Latinoamericano de Asistencia Regional (CELAR). The Emergency Preparedness and Disaster Relief Co-ordination Programme of PAHO aims to enhance the preparedness of the health sector through training, public awareness and contingency planning. In addition, it offers a variety of services including international and local courses and workshops, simulation exercises for emergency committees; dissemination of technical manuals, etc.

CELAR, founded in 1985 during the Second Latinamerican Colloquium on Regional Assistance, operates under the responsibility of the Social Solidarity Fund Foundation (FUNDASOCIAL) which depends on the Ministry of Internal Relations of Venezuela. It offers an annual Course for Civil Defence and Protection Officers at a senior level. At present it also offers courses for medium and high level officials of National Civil Protection systems in various countries of the region.[157]

For the last 18 years ECLAC has been assisting governments in assessing the social and economic impact of natural hazard caused disasters. The objective of this work is to provide both the governments of affected countries and the international donor community with information to help define post-disaster priorities for reconstruction. A large number of reports have been prepared on the direct and indirect damages caused by disasters, on the impact of disasters on economic development and on the identification of rehabilitation and reconstruction projects (see annex 4).

The United Nations Disaster Relief Organization (UNDRO) promotes co-operation in the region in many areas related to disaster relief. UNDRO organizes meetings and seminars, as well as acting as a vehicle for technical co-operation in all aspects of disaster management.

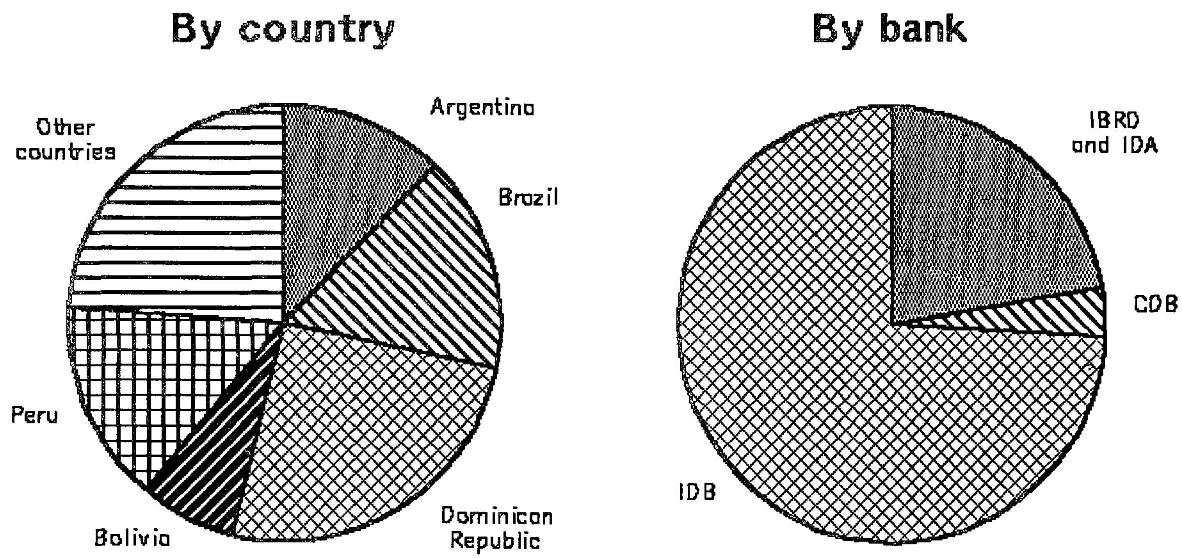
Co-operation in the field of disaster mitigation has achieved its highest development in the region in the Caribbean. This can be explained both by the characteristics of the predominant natural hazards, tropical cyclones affecting several countries at the same time, and by the relatively small territories of most Caribbean countries, devastation from a single even may extend over the entire territory making emergency response difficult without external assistance. Both these factors and the tragic accumulation of hazard events in the late seventies when several Caribbean countries experienced a series of severe natural disasters encouraged the development of formal co-operation measures.

The major initiative towards co-operation in the Caribbean was the adoption by ECLAC of a resolution, October 1979, later endorsed by the General Assembly of the United Nations, whereby, "the United Nations, and more particularly the Office of the United Nations Disaster Relief Co-ordinator, should study ways and means of setting up specific machinery to cope with the natural disasters that periodically occur in the Caribbean Basin".[158]

The task of "setting up specific machinery" was realized through the creation, under the auspices of UNDRO, of the Pan-Caribbean Disaster Preparedness and Prevention Project (PCDPPP) which formally initiated its activities in September 1981. The geographical scope of the PCDPPP includes all Caribbean island states and four adjacent mainland countries: Belize, French Guyana, Guyana and Suriname. The objective of PCDPPP is to contribute to socio-economic development and environmental protection by developing the individual and collective capacity of the participating countries to mitigate the disastrous effects of natural hazards and to cope efficiently with disasters when they occur. This objective is achieved through the promotion and facilitation of the adoption of disaster mitigation measures both at the national and regional levels.[159]

The other area in which there is co-operation within the region is in the provision of emergency aid. Humanitarian aid is freely provided among the countries of the region and, in addition, the multi-lateral development banks, the World Bank (IBRD), Inter-American Development Bank (IDB) and the Caribbean Development Bank (CDB) have made a limited number of loans for rehabilitation following water-related disasters. The largest loan was that made to the Dominican Republic, equivalent to 25.47% of all loans identified for this purpose, following hurricane "David". In general, however, such loans have been very modest, less than 1% of the loans made by the multi-lateral banks between 1973 and 1987, and sizeable loans have only been made in a few cases (figure 17).[160]

Figure 17
LOANS FOR WATER-RELATED DISASTER REHABILITATION, 1973-1987



Source: annual reports of respective banks.
Note: the amount of loans has been calculated in constant 1980 US dollars.

Part Three

WATER POLLUTION *

* This document was published by ECLAC under the symbol LC/L.499, 8 May 1989.

Introduction

A hallmark of the second part of the twentieth century in the use of the water resources of Latin America and the Caribbean has been the emergence of pollution as a significant and alarming feature of many water bodies. There are very disparate factors which account for this increase in pollution. Among the more important are rapid population growth, particularly the urban population, improvement in the provision of drinking water supply and sewerage services, the expansion of industry and the technification of agriculture —all this unaccompanied by the development of waste treatment facilities and pollution control. Together, these factors have led to the emergence of the control of water pollution as a major challenge for water management in the region.

The growing seriousness of water pollution in the region can be seen in the decline in the quality of the waters of rivers with large volumes of flow, such as the Cauca and Magdalena in Colombia, the Mantaro in Peru and in the rivers of the La Plata system. The situation is far worse, however, in many smaller rivers, lakes and lagoons where the impact of pollution tends to be relatively greater.

There is a complex and specific set of relationships between human activity, the generation of waste flows, absorbing capacity and the resulting contamination of any water body.

It is known that one of the major causes of water pollution in Latin America and the Caribbean is the discharge of untreated or inadequately treated domestic and industrial waste water. Non-point source pollution from the percolation, precipitation and/or unregulated run-off of contaminated water can also be important. Water pollution can be caused by natural factors, but this is usually of lesser significance; however, Lake Managua in Nicaragua is seriously contaminated from volcanic sources.

There has been no systematic regional evaluation of the evolution of water pollution in Latin America and the Caribbean or of its impact on the welfare of the population and its economic consequences. At the same time, the overall magnitude of the pollution of the region's water resources is not known. This report provides a description based on existing reports and information of the state of water pollution in the region and of the efforts being made by governments to control it and to improve water quality management.

I. WATER POLLUTION CAUSED BY POINT-SOURCE WASTE DISCHARGES

A. OVERALL PATTERNS

In Latin America and the Caribbean, one of the main causes of water pollution is the direct discharge of domestic sewage and industrial effluent. Of these two contaminants, domestic sewage is usually the more important, particularly in large population centres. For example, it has been estimated that in Rio de Janeiro, Brazil, 70% of the pollutants in the recipient waters around the city are of human origin while only 30% are industrial and organic wastes. Storm-water run-off is a further source of pollution in major urban areas of the region.

There is a general absence in the region of waste water treatment plants for any but the most toxic industrial wastes. Virtually all municipal sewage and industrial effluent is discharged into the nearest rivers and streams without any treatment. In most major cities even the patterns of waste flows are only partially controlled through interceptor sewers and scientifically located outfalls.

The geographical pattern of water pollution from point-source waste discharges in Latin America and the Caribbean is dominated by the flows originating from large metropolitan areas, although water bodies in areas of non-metropolitan concentrations of mining and manufacturing industry also receive significant waste discharges.

A high proportion of industry and population is concentrated in relatively few regions, such as the Lower Parana-River Plate area of Argentina and Uruguay, the triangle of Rio de Janeiro/São Paulo/Belo Horizonte in Brazil, and the Mexico City metropolitan region in Mexico. Elsewhere, the largest cities usually account for a substantial part of both total population and total industrial production. For example in Peru, the Lima metropolitan area, which in 1980 comprised 27% of the total population, but accounted for 43% of GDP and more than 90% of capital goods production (table 13).

In the future, demands on the water resources adjacent to metropolitan regions for the disposal and transport of industrial and domestic wastes are likely to increase due to continued growth in population and industrial development. The limited financial resources and economic difficulties facing the countries of the region are likely to inhibit a parallel expansion of efficient water pollution control and the installation of the waste-treatment facilities required.

B. MAIN POINT-SOURCE WASTE DISCHARGES

1. Domestic sewage

The average sewage production *per capita* usually ranges between 30 and 100 litres per day, although much higher figures can occur. For example, in Santiago, Chile, in 1984 the waste water discharge *per capita* per day was estimated to be 400 litres.[161] The main ingredient of domestic sewage —99% or more by volume— is water. Dry organic matter, the most active portion of sewage, can constitute as much as 60%-70% of the total dry matter. The organic matter present in domestic sewage usually consists of carbohydrates, fats, proteins, oils, surfactants and agricultural trace compounds. Since some portion of the population carries various diseases, domestic sewage is infected by pathogenic organisms, the most significant of which are coliform bacteria, faecal streptococci, helminthic eggs, protozoa, salmonella typhosa and various viruses.[162] The bacteriological load of raw domestic sewage in Latin America usually varies between $10 * 10^6$ and $10 * 10^7$ coliform bacteria per 100 ml.[163] Domestic sewage in Latin America tends to have high biological oxygen demand (BOD), suspended and dissolved solids characteristics, while the fat content is generally low (table 14).

Domestic sewage is biodegradable. Its chemical composition permits relatively rapid decomposition by natural processes in water bodies or in engineered systems. However, owing to large population concentrations and a lack of sewage treatment facilities, the input of sewage into the environment in many locations in Latin America and the Caribbean exceeds the natural decomposition and dispersal capacity of the recipient water bodies. The result is a significant degradation of the quality of water. The percentage of domestic

Table 13

LATIN AMERICA AND THE CARIBBEAN: MAJOR METROPOLITAN AREAS, POPULATION AND RECIPIENT WATER BODIES FOR WASTE FLOWS

Metropolitan area	Recipient water body	Year	Population	As a % of the population of the country
Mexico	River Tula and Lerma/Panuco	1980	13 368 315	20.0
São Paulo	River Tiete and Lake Billings	1980	12 183 634	10.2
Buenos Aires	River Plate and tributaries	1980	9 969 826	35.7
Rio de Janeiro	Guanabara Bay and Atlantic Ocean	1980	8 821 845	7.4
Lima	Pacific Ocean	1981	4 608 010	27.1
Bogotá	River Bogotá	1985	3 974 813	13.8
Santiago	River Mapocho	1982	3 902 356	34.4
Caracas	River Guaire and Tuy	1981	2 640 013	18.2
Belo Horizonte	River Das Velhas and others	1980	2 461 081	2.1
Guadalajara	River Santiago	1980	2 221 053	3.3
Porto Alegre	River Guiba	1980	2 178 079	1.8
Recife	Atlantic Ocean	1980	2 131 649	1.8
Medellín	River Medellín	1985	1 963 850	6.8
Havana	Gulf of Mexico	1981	1 929 432	19.8
Monterrey	River Santa Catarina	1980	1 913 075	2.9
Salvador	Atlantic Ocean	1980	1 696 318	1.4
Fortaleza	Atlantic Ocean	1980	1 501 469	1.3
Montevideo	Atlantic Ocean	1985	1 449 975	49.5
Santo Domingo	Atlantic Ocean	1981	1 313 172	23.3
Cali	River Cauca	1985	1 367 452	4.8
Curitiba	River Belem	1980	1 325 275	1.1
Guayaquil	River Guayas and Salado estuary	1982	1 175 973	14.6
Brasilia	River Paranua Sta. Maria	1980	1 139 480	1.0
Barranquilla	River Magdalena	1985	1 122 511	3.9
Guatemala	River Maria Linda	1981	1 098 476	18.1
Maracaibo	Lake Maracaibo	1981	1 013 939	7.0
Total			88 471 071	21.3

Source : Latin American Demographic Centre, América Latina en el año de los 5.000 millones, Santiago, Chile, 1987, p. 36.

Table 14

CHARACTERISTICS OF DOMESTIC WASTEWATER, SELECTED LATIN AMERICAN COUNTRIES

Characteristic	"Typical" composition (mg/l)	Uruguay (mg/l)	Mexico (mg/l)	Colombia[a] (mg/l)	Chile[b] (mg/l)
Biological oxygen demand	200	260[c]	299	241	109[d]
Chemical oxygen demand	500	n/a	719	n/a	n/a
Solids, total	700	n/a	n/a	n/a	1 059
Suspended solids, total	200	275	309	289	91
Suspended solids, non-settleable	150	193	n/a	n/a	n/a
Suspended solids, settleable	50	7	n/a	n/a	n/a
Dissolved solids, total	500	n/a	830	n/a	968
Nitrate (as N)	40	n/a	n/a	33.8	28
Nitrate, ammoniacal	25	n/a	28	n/a	n/a
Nitrate, organic	15	n/a	23	n/a	n/a
Phosphore (as P)	10	n/a	n/a	2.9	n/a
PPO_4, total	n/a	n/a	25	n/a	n/a
Oil and fat	100[e]	n/a	44	10.8	31[e]

Source : CEPAL/CPPS/PNU/UIFSM, Valparaíso, Chile, Descontaminación de la Bahía, anexo 1; Walter A. Castagnino, "Polución de agua, modelos y control", Serie técnica, 20, CEPIS, Environmental Health Division, Pan-American Health Organization, p. 5; H. Weitzenfeld and J. Barrios, "Water Pollution in Cartagena Bay, Colombia", Water Quality Bulletin, vol. 9, No. 4, October 1984, p. 216.

[a] Cartagena Bay.

[b] Melipilla.

[c] $(DBO)_5$.

[d] $DBO_{5, 20}$.

[e] Fat.

n/a = Not available.

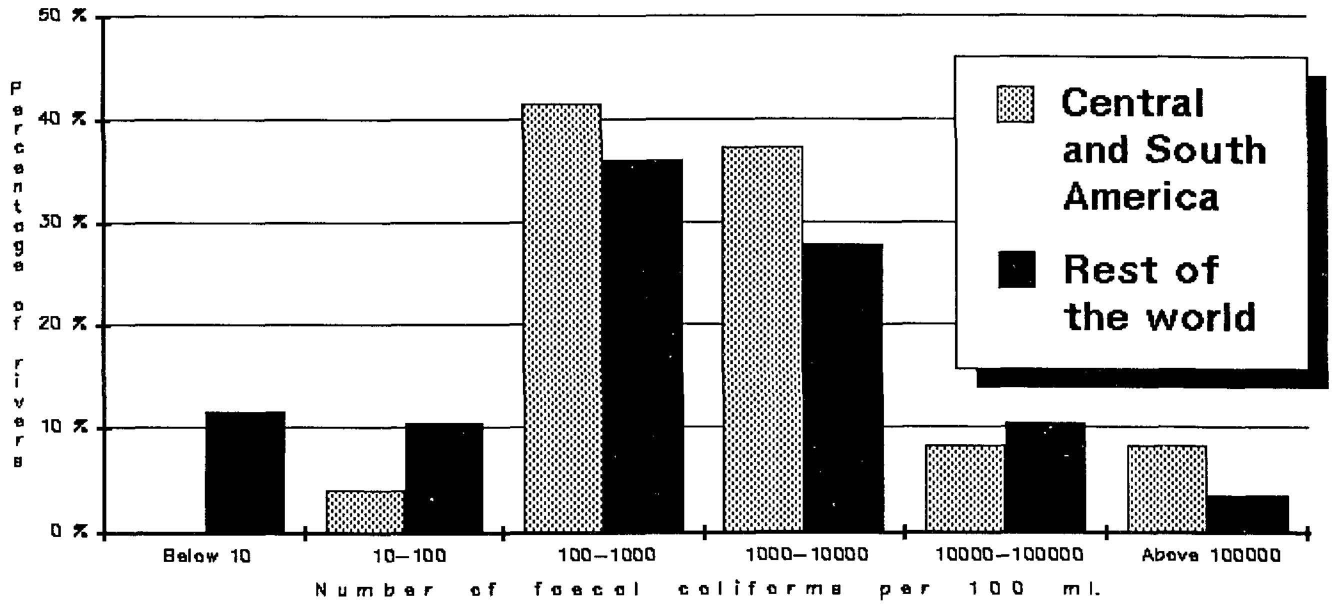
wastes currently treated is not known, but estimates suggest that less than 2% of total urban sewerage flows receive treatment.[164]

Some idea of the current demand for the use of water bodies for domestic waste disposal and transport can be gained from the fact that in 1980 total domestic-municipal return water in South America has been estimated at some 127 m^3/sec, representing 4.2% of the world total whereas in 1950 these figures were 29 m^3/sec and 3.9% respectively. Waste flows can be very significant in the largest metropolitan areas and can be expected to increase as the population served by sewerage in the region grows. The served urban population increased by 18% between 1980 and 1985 and is expected to increase by a further 39% by 1990. Estimates of the outflow and parameters of domestic sewage for cities with 100 000 inhabitants or more in 1980 and the recipient water bodies of these discharges are given in annex 5.

A direct and sensitive measure of the overall state of pollution of water bodies by domestic sewage is obtained by counting indicator organisms such as faecal coliforms. Information on such counts is not available for the majority of the region's water bodies, but recent data on 24 major or regionally representative Central and South American rivers (figure 18) suggests that the situation in the region may be, on average, worse than in other parts of the world. For example, whereas 22% of the monitored rivers of other regions were of other regions were characterized by faecal coliform counts of less than 100 per 100 ml and 58% of these by counts of less than 1 000 per 100 ml, in contrast, the corresponding indices in Central and South America are 4% and 46% respectively. Eight percent of the rivers monitored in Central and South America have faecal coliform counts of more than 100 000 per 100 ml; in the other regions only 4% of the rivers are polluted to such a degree.[165]

Demands on water resources for the disposal and transport of domestic waste and the resulting potential for pollution can be expected to expand enormously in the region by the end of the century. For example, they will more than double in Sao Paulo, Brazil, although treatment is planned (table 15). Although the population of many of the major metropolitan areas is expected to more than double, population growth will be only one factor responsible for the rise in the demand on water resources. Equally significant will be the increased flows through sewerage systems as drinking-water-supply and sewerage connections are extended to a larger proportion of the population and individual water use increases. At present, in many metropolitan regions less than half of the population is served by sewerage systems, and water use *per capita* is substantially lower than in Europe and North America. Treatment

Figure 18
FAECAL COLIFORMS IN RIVERS MONITORED BY THE GLOBAL ENVIRONMENT MONITORING SYSTEM



Source: Global Environment Monitoring System (GEMS).

Table 15

SAO PAULO, BRAZIL: CURRENT AND PROJECTED DEMAND FOR SEWERAGE TREATMENT

Estimated sewage/BOD	1975	1980	1985	2000
Sewage in m3/sec	21.0	26.0	42.0	94.0
Index	100	124	200	448
Estimated BOD (mg/l) in the river (without project)[a]	80	120	150	250
Index	100	150	188	313

Source: L. V. Chang, "Wastewater pollution control in São Paulo, Brazil, Water Quality Bulletin, vol. 7, No. 2, April 1982, p. 80.

[a] Estimated BOD_5 in water courses after dilution of total sewage with river flows.

facilities can, however, be expected to be built and in a number of major metropolitan areas, including, for example, Bogotá, Colombia, and Santiago, Chile, plans for the construction of primary treatment plants are well advanced.

2. Industrial effluents

The process of industrialization in Latin American and Caribbean countries has contributed to the increased occurrence of water pollution. In many countries practically all but the most toxic industrial effluent is discharged into the nearest water bodies without adequate treatment. For example, in Ecuador industrial effluent has been reported to be generally discharged into water bodies without treatment or the taking of precautions.[166] In other countries the situation is often similar. In Argentina retention of the waste load generated by industry does not exceed 10%;[167] while in the Maipo river basin in Chile, only 25.6% (18.0% if only manufacturing industry is taken into consideration) of industrial effluent receives treatment (figure 19), although for the region as a whole, this represents a relatively high degree of waste treatment. Even when treatment facilities do exist, they are not always well maintained or the technology employed is not always the most adequate.

There is no information from which to determine the overall impact of industrial waste flow on the region's water bodies. It has, however, been estimated that industrial effluents constitute 90% of overall water pollution in Mexico, the contribution from agriculture not having been taken into consideration; while in Colombia industry is estimated to be responsible for some 50% of water and air pollution.[168] The total return water flows from industry and power production in South America were estimated at some 254 m^3/sec in 1980. This is almost four times higher than the flows in 1950 but represents only 1.3% of the estimated world total.

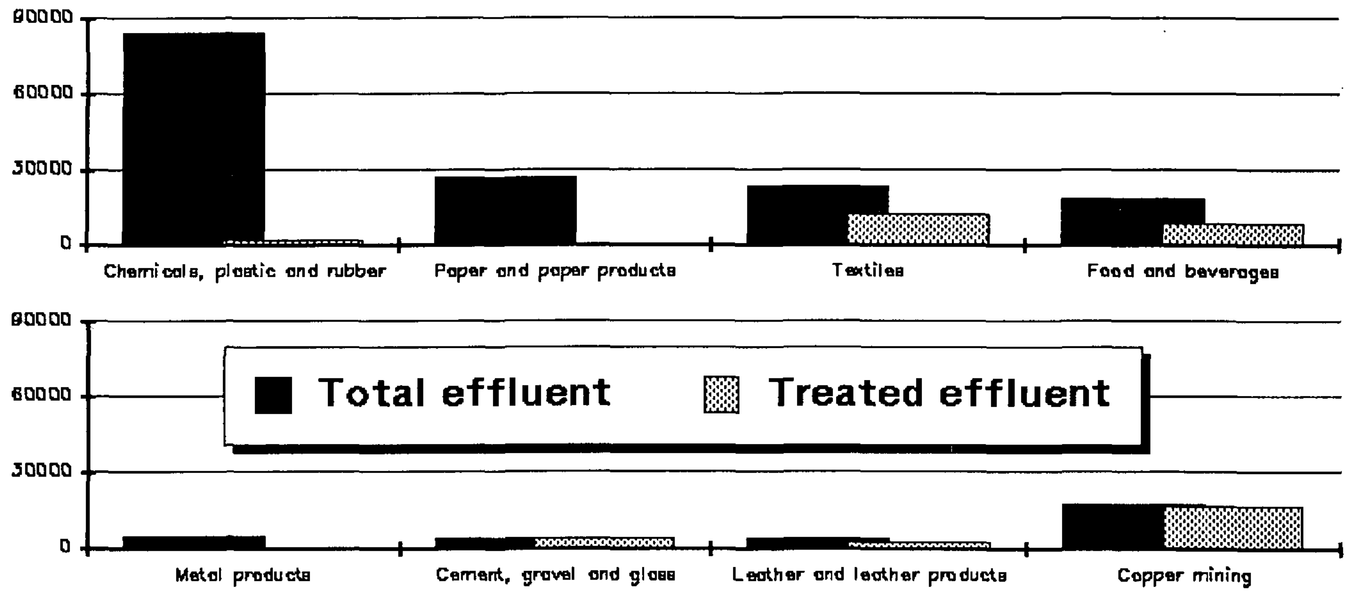
Demands on the water resources for the disposal and transport of industrial wastes and subsequent pollution problems can be expected to continue to increase. For example, both the pulp and paper and the iron and steel industries, which rank among the most important industrial sources of water pollution in the region, have been growing twice as fast as the economy of Latin American countries as a whole.[169]

a) *Effluent flows from manufacturing*

In manufacturing, water is used in cooling, chemical treatment, transport, washing and other similar operations, many of which cause a deterioration of its quality. The characteristics of water use in selected industrial sectors are shown in figure 20. Of all the pollution caused by industry, chemical and biological pollution undoubtedly ranks foremost in the region owing both to the high toxicity and non-degradability of industrial pollutants and to the characteristics of the industrial structure.

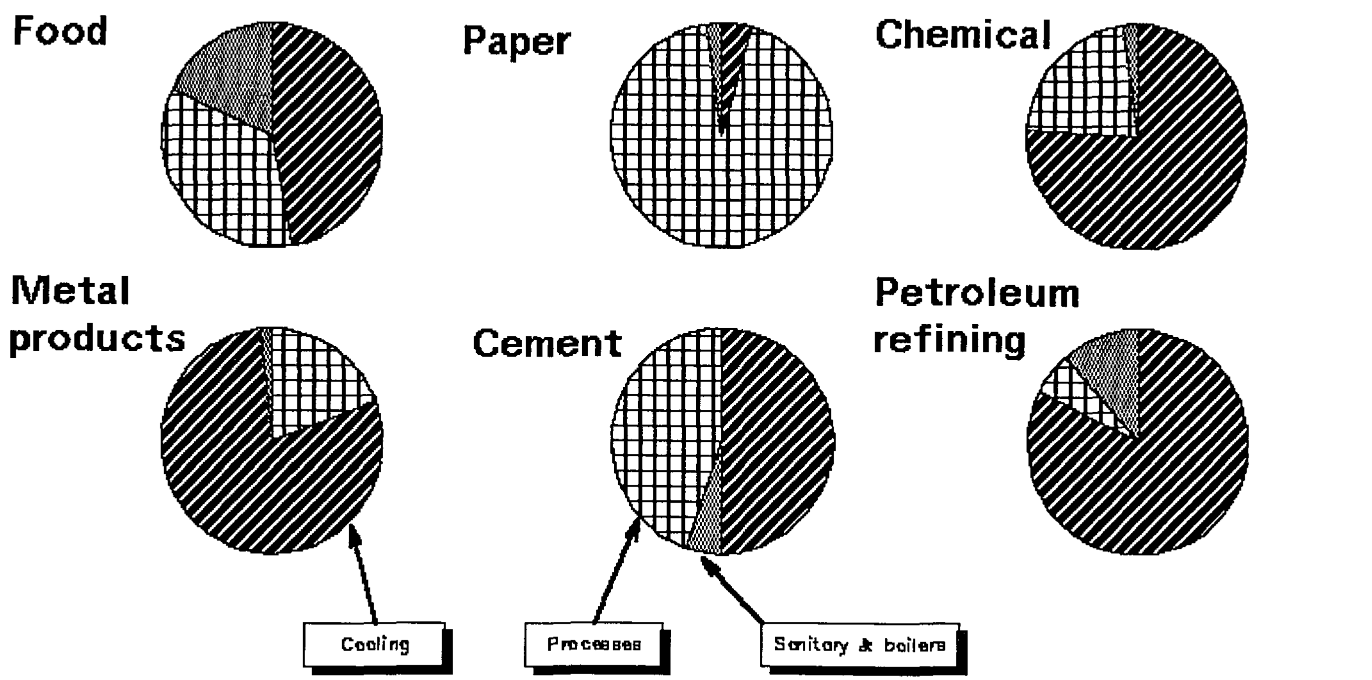
i) Chemical and biological pollution. The nature and quantity of pollutants vary in relation to products, processes and technology. Industrial waste waters may contain heavy metals, soluble organics causing depletion of dissolved oxygen, various toxic substances, acid-producing compounds, oil and fat, phenols, colloidal solids, dissolved trace refractory organics, colour and turbidity, suspended solids, nutrients (nitrogen and phosphorus compounds) and other organic and inorganic substances. Many of their components are resistant to biodegradation.

Figure 19
TREATMENT OF INDUSTRIAL EFFLUENT IN THE MAIPO RIVER BASIN, CHILE (cubic meters per day)



Source: Contaminacion marina en Chile, Ministerio de Salud, Santiago, 1979, p. 18.

Figure 20
WATER USE BY INDUSTRY



Source: Walter A. Castagnino, Polucion de agua, modelos y control, CEPIS, Organizacion Panamericana de la Salud, p. 12.

Industrial water use in the majority of the countries of Latin America and the Caribbean accounts for a relatively minor part of total water withdrawals. In those countries with a higher degree of industrial development, however, chemical and biological contamination from the effluents of manufacturing rivals domestic wastes as a source of water pollution. Locally it can be extreme. This phenomenon is due both to the nature of the predominant pollutants and to the fact that their toxicity tends to be very high. In metal-ore mining, for instance, the population equivalent of wastes per employee has been put at 40, while in the factories and refineries of the sugar industry which is also widely developed in the region, it is, on average 999.[170] Characteristic of the situation in the region as a whole is the fact that in El Salvador, the manufacturing labour force in 1980 comprised 247 621 persons, but the population equivalent of the industrial effluent was estimated to be equal to that of the population of the whole country —almost 5 million— a ratio of 1:19 (see table 16).[171]

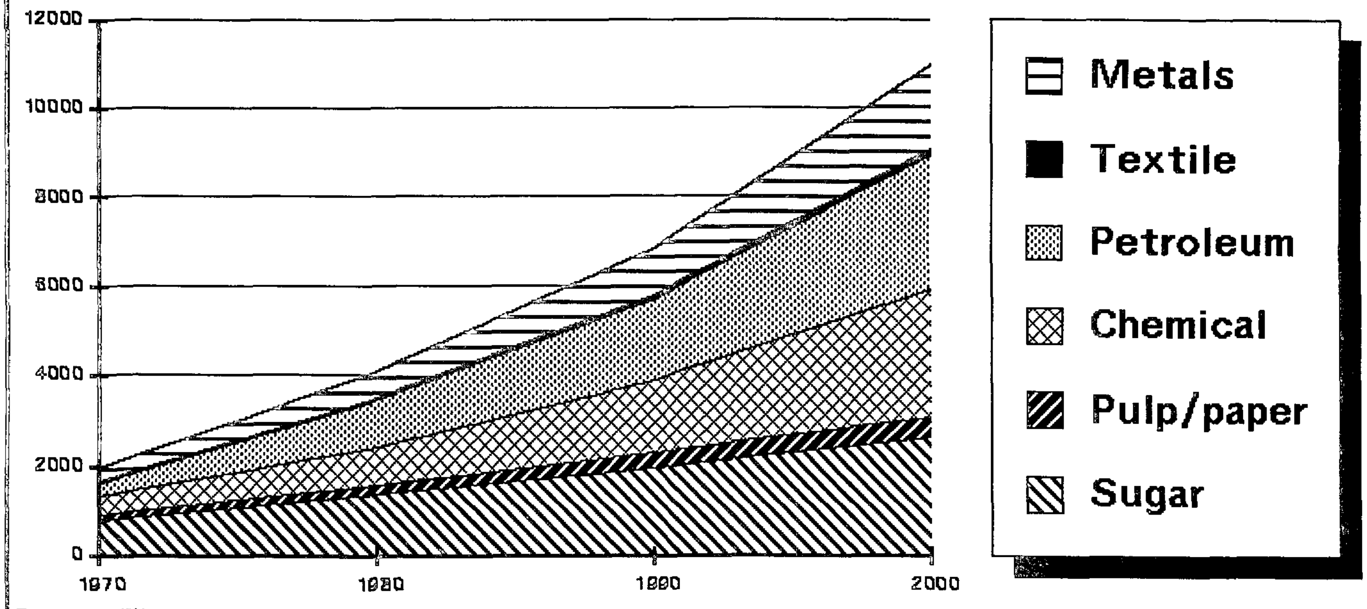
It appears that the region has a higher share of industries with potentially noxious effluents than the world as a whole. For example, while the share of Latin America in the world total value added in industry was 5.3% (1983), its share (1982) in petroleum refining was 17.7%; in the production of other chemicals, 14.7%; in the number of beverage industries, 11.4%; in food manufacturing, 8.7%; in iron and steel basic industries, 7.1%; in non-ferrous basic industries, 6.3%, and in paper products, 5.4%.[172]

The major industrial waste loads in the region are generated by the pulp and paper, chemicals and petrochemicals and petroleum refining, metal-working (particularly iron and steel production and non-ferrous metal refining), food processing (particularly sugar in major producing countries), fish-meal, coffee-processing, thermal electricity generation and the textile industries. Some idea of the extent of the contribution from different industries can be gained from figure 21 showing the dynamic of waste water discharges by industrial sectors in Mexico. The location of these industries in relation to water bodies is shown in annex 6.

Insufficient data hampers any quantitative evaluation of the contribution of each industry to overall industrial water pollution; however, some idea of the extent of their potential contribution can be gained from process characteristics:

- *Pulp and paper industry.* Waste water discharges from the paper and pulp industry are among the greatest pollution hazards for the region's water bodies. Its pollution flows are mainly related to its bleaching, paper-coating, screening, washing and wood preparation and pulping processes. The typical effluent from a pulp

Figure 21
ESTIMATED RESIDUAL WATER DISCHARGES BY INDUSTRIAL SECTORS IN MEXICO (million cubic meters per year)



Source: SARH.

Table 16

POPULATION EQUIVALENT OF MANUFACTURING INDUSTRY EFFLUENTS IN EL SALVADOR

Industry	Number of plants	Population equivalent of the industry effluent
Coffee processing	211	2 123 357
Sugar	11	1 590 718
Processing of American agaves	4	694 535
Distilling	3	193 808
Tanning	14	85 872
Dairy	10	24 165
Textiles	19	23 604
Slaughterhouses	42	18 435
Paper	2	11 414
Total	316	4 765 908

Source : *Resumen general sobre recursos y demandas*, Plan maestro de desarrollo y aprovechamiento de los recursos hídricos, El Salvador, Documento básico No. 14, PNUD/ELS/78/005, May 1982, Table No. 43.

and paper industry contains chlorinated organic compounds; colloidal solids; dyes; fat; colours; dissolved trade refractory organics; nutrients, such as nitrogen and phosphorus; oil; phenols and various other organic pollutants.[173]

Paper and pulp plants produce, on average, 200 m^3 of effluent per ton of cellulose pulp and 110 m^3 per ton of paper, although figures vary enormously from plant to plant.[174] The potential volume of effluent generated by the industry in the region is estimated at some 27 m3/sec.[175]

- *Petroleum refining*. The products and production processes used in petroleum refining are varied, and the contaminants of the waste water discharges are similarly diverse. They range from phenols, other organic pollutants and suspended and dissolved solids to alkaline and caustic sludge, cyanides, heavy metals and sulphides.

Petroleum refining produces, on average, 380 litres of effluent per barrel of crude oil refined, although figures can vary depending upon the technology employed.[176] The potential volume of effluent can be estimated at some 24 m^3/sec.

Refineries located on the coast can represent a greater hazard for the aquatic environment than seabed petroleum extraction. It has been estimated that in the Caribbean refineries account for almost twice the volume of petroleum hydrocarbon residuals due to exploration and production activities. At the same time refined products may pose a more serious long-term threat than crude oil since they tend to be much more persistent and long-lived in the marine environment.[177]

- *Iron and steel production.* Various processes in the production of iron and steel give rise to waste water discharges. These include the preparation of raw materials, sintering and coke-making processes, the operation of blast furnaces and hot rolling mills, pickling operations, the operation of cold mills and coke plants and the finishing of steel products. Depending upon the process in which water is used, effluent may contain ammonia, cyanides, oils, phenols, fluorides, ferrous chloride, emulsions, sulfuric acid, ferrous sulphate, hydrochloric acid and large amounts of suspended solids.

The iron and steel mills generate, on average, 25 m^3 of effluent per ton of production, although the amounts per individual mill vary substantially. The potential volume of effluent generated by the industry in the region is estimated at some 25 m^3/sec; and the annual potential pollution load from untreated effluent, at 1 762 700 tons of suspended solids, 910 tons of phenols, 400 tons of cyanide, 1 100 tons of nitrogen (ammonia), 38 500 tons of mineral oils and 1 100 tons of iron.

- *Non-ferrous metal refining.* The effluent from the non-ferrous metal refining industry is an important source of water pollution in several countries of the region. Depending upon the characteristics of the primary mineral being processed and of the other minerals in the ore, effluents may contain high concentrations of arsenic, lead, cadmium, copper, nickel, zinc and other harmful, non-degradable substances.

Non-ferrous metals refineries generate, on average, 20 m^3/sec of effluent per ton of production, although much higher and lower figures may also be recorded depending upon the technology and equipment employed. The potential volume of effluent generated by these plants in the region is estimated at 4 m^3/sec, of which copper smelting and refining probably account for more than half.

- *Food processing and related industries.* Food processing industries are important dischargers of suspended and colloidal solids and organic pollutants. For example, brewery wastes show a high BOD with an elevated carbonaceous soluble component. They also contain high concentrations of organic matter and suspended solids. Dairy wastes are also characterized by very high BOD. They contain organic compounds which, although initially neutral or alkaline, tend to acidify rapidly, posing treatment problems. Cannery waste may contain large amounts of oil and grease in addition to high BOD, solid materials, dissolved or colloidal compounds, soda and citric acid. Discharges from meat and poultry processing and packing show considerable concentrations of blood and excreta with elevated levels of the bacteria salmonella. The wastes contain high levels of organic compounds and suspended solids and also of nitrogen and grease.[178]

The food manufacturing industry produces, on average, 2 050 m^3 of effluent per employee annually, although again figures can vary substantially from plant to plant depending upon the equipment and technology used.[179] Thus, the potential discharge of effluent by processors in 19 Latin American and Caribbean countries [180] can be estimated at about 60 m^3/sec.[181] It should be noted that because of the seasonal nature of the production of some branches of the food processing industry, much of their effluent is likely to be discharged during a few months, which increases their potential for pollution, particularly if the period of discharge coincides with the period of low flow.

In many countries, it is known that these industries are important contributors to water pollution. For example, it has been estimated that in Argentina food, beverage and tobacco industries account for some 59% of the potential pollution generated by industry.[182] In the Maipo and Marga-Marga river basins in Chile, the food and beverage industry generates 11%-14% of industrial wastes (excluding those generated by copper mining).[183]

- *Sugar production.* In recent years, Latin America and the Caribbean produced some 26 000 000 - 28 800 000 tons of centrifugal sugar. The sugar refining industry is developed in virtually all the countries of the region. Brazil and Cuba are the largest producers, accounting for nearly 60% of total production in 1984.[184]

The sugar industry produces, on average, 3 m^3 of effluent per ton of production in the case of cane sugar and 40 m^3 in the case of beet sugar. The potential volume of effluent discharged can be roughly estimated at about 3 m^3/sec. However, due to the seasonal character of this industry, discharges tend to be concentrated during a relatively short period of time. In El Salvador, for example, the period of discharge lasts 5 months —from November to March.[185] During this period effluent is likely to be discharged at a rate of about 8 m^3/sec. This explains why the sugar industry and related industries put a considerable strain on the water resources of the main producer countries. In Brazil pollution by sugar industry effluent has been reported to be particularly high in the states of Sao Paulo and Pernambuco.[186] Relatively small and irregular run-off heightens the impact of sugar industry effluents in Caribbean countries.

The distilling and rum industries associated with the sugar industry produce a strong organic waste containing yeast. It is characterized by a BOD of 1 200 - 2 000 mg/l and a pH of 3.0 and has a strong aromatic odour.[187] Brazil produces a large volume of alcohol fuels from sugar cane. The production of such fuels grew by 35% annually between 1975/1976 and 1985/1986, reaching 11.1 billion liters in the latter season.[188] Problems associated with the water pollution caused by distilling and rum industry effluent exist in several countries of the region.[189]

- *Coffee-processing plants.* In Latin America and the Caribbean, more than 17 500 000 tons of coffee berries are processed annually. The bean is known to comprise only 44% of the weight of the average coffee berry, the remainder being made up of pulp and mucilage. It is estimated that processors discard about 10 000 000 tons of waste every year, which is dumped in rivers and elsewhere, creating pollution and even constituting a health hazard. By comparison, Africa, Asia and Oceania together generate only about 6 900 000 tons of coffee waste.[190] As in the case of the food and sugar industry, the bulk of the coffee-processing effluent is discharged during a few months.

One of the most typical coffee-processing-related water pollution problems in the region is caused by the wet depulping process which is widely used in Central America, particularly in El Salvador and Guatemala, but is also used in some South American countries, such as Brazil and Colombia. This process requires high volumes of water. In Colombia 12 litres of water are used to produce one kilogram of washed coffee beans. Expensive treatment methods are not used because coffee farms are often very small, there are 3 000 plants in Guatemala, and the effluent from them is discharged directly into nearby streams. Moreover, one of the by-products of the wet depulping process is an organic residue which is left in mounds on river banks, the leachate augmenting the organic load and the BOD.[191]

- *The fishing industry.* Effluent from the fishing industry is an important source of contamination of coastal waters near large fish-processing and fishmeal factories. Pollution tends to be a particularly acute problem when factories are located on the shores of bays characterized by weak currents.

The fishing industry is widespread in the region but is particularly highly developed in Chile and Peru. It has been reported that some 41 tons of fishing industry wastes are dumped into the coastal waters of the northern zone of Chile daily.[192] In Peru pollution caused by the fishing industry affects the coastal waters adjacent to several ports.[193]

Apart from pollution caused by fish blood and absorbent water, fishmeal factories produce highly contaminated effluent characterized by an extremely high BOD (70 000 mg/l). In quantitative terms, effluent (other than absorbent water and fish blood) generated by fishmeal plants amounts to, on average, 23% of the tonnage produced. The estimated potential volume of effluent from the fishmeal industry in selected Latin American and Caribbean countries is given in table 17.[194]

- *Energy production.* Water pollution caused by energy production is primarily physical pollution resulting from thermal discharges into bodies of water. Thermal discharges sometimes contain certain trace chemicals, but this is usually a minor problem. Hydroelectric projects can have a negative impact on the chemical and biological quality of water as a result of the flooding of forests. Experiences with the Curuá-Una Dam in Brazil and the Brokopondo Dam in Suriname show that decomposition of submerged forest can lead to the production of hydrogen sulphide and other harmful substances that pose serious public health risks and threaten a dam's machinery. Other adverse effects associated with reservoirs include massive fish kills and infestation by aquatic weeds.[195]

ii) *Physical water pollution.* Manufacturing affects water quality not only through effluents containing chemical substances and biological agents but also through physical contamination. In its most common form, such contamination is caused by thermal discharges into water bodies. The most apparent effects of thermal inputs are the rises they produce in water temperature. This can affect aquatic animals and plants, increase evaporation and reduce the availability of dissolved oxygen, which may have adverse consequences for water quality.

Cooling water accounts for between 60% and 70% of all the water use by industry and for as much as 90% of such water if thermal electric power production is taken into consideration.[196] Significant amounts of cooling water are discharged from iron and

Table 17

SELECTED LATIN AMERICAN AND CARIBBEAN COUNTRIES: ESTIMATED POTENTIAL VOLUME OF EFFLUENT FROM THE FISHMEAL INDUSTRY

Country	Estimated effluent (m^3/day)	Country	Estimated effluent (m^3/day)
Argentina	9	Mexico	41
Brazil	16	Panama	29
Chile	701	Peru	452
Cuba	11	Uruguay	7
Ecuador	192	Venezuela	4

Source: Information taken from Walter A. Castagnino, "Polución de agua, modelos y control", *Serie técnica*, 20, CEPIS, Environmental Health Division, Pan-American Health Organization, p. 14; FAO, *1985 Yearbook of fishery statistics, fishery commodities*, Vol. 61, Rome, 1987, pp. 98 and 234.

steel and pulp and paper mills, chemical and petrochemical plants, thermal electric power generating stations, etc. Thermal electric power generating stations are by far the largest contributors of thermal discharges into the aquatic environment. Thermal pollution is also caused by domestic sewage, but this is usually the least important source.

In contrast to other forms of industrial water pollution, thermal pollution does not at present, seem to represent any visible threat to the region's water bodies. The climates prevailing in the region, the relatively low level of use of thermal plants in energy production, the large amount of water resources available and other factors reduce the problem. It has, however, been reported that in Peru the discharge of refrigerating waters in the bay of Chimbote (0.4 m^3/sec) has negatively affected aquatic fauna.[197]

b) ***Mining and the processing of minerals***

Water, usually in very large quantities, is an essential element in every stage of the development of mineral resources —mining, concentration and processing. Water pollution is regarded the most hazardous environmental problem associated with the mining industry. The pollutants emitted by the mineral industry are, in order of importance, toxic metals, acid and solids in suspension.[198] The degree of water pollution caused by mining and the processing of minerals is determined both by the characteristics of the primary mineral being processed and/or of other minerals in the ore and by the technology used.

In order to evaluate the impact of the mineral industry on the water resources of Latin America and the Caribbean, the following important factors should be taken into consideration:

- The mineral industry plays a key role in the economy of many Latin American and some Caribbean countries and has been characterized by high growth rates (see annex 7).

- Usually the simplest means of mineral recovery (which are frequently used in the region) result in the greatest water pollution problems.

- Most chemical pollutants (toxic metals and acid) are known to result from oxidation of the minerals being mined and in particular from the oxidation of sulphide minerals. Many of the important metals produced in the region are mined as sulphides (including copper, zinc, lead, nickel, silver, mercury, cadmium and arsenic), and sulphides occur in many of the minerals not mined as sulphides.[199]

- Many mines and mineral processing plants dump their wastes in small, isolated rivers and streams which bring pollution directly to the sea.

- The minerals industry also produces huge quantities of solid wastes and also have certain other potentially detrimental effects on the environment, which may in certain circumstances cause water pollution including physical water pollution, and/or aggravate water pollution problems which already exist. For example, in Peru it has been considered necessary to dredge Lake Junin, the source of the Mantaro river, to remove the mineral residues which have accumulated over several decades.[200]

i) Mining. Pollution from mining affects many water bodies and some coastal areas in nearly all South American countries and poses a particularly acute problem in the Andean countries, especially Chile and Peru (table 18).[201] Chile produces coal, copper, gold, iron, lead, manganese, mercury, molybdenum, saltpeter, selenium, silver, sulphur and zinc. Peru produces antimony, arsenic, bismuth, coal,

Table 18

EFFLUENT FROM THE MINING INDUSTRY IN PERU

Location	Number of points of discharge	Treatment yes/no[a]	Total volume of effluent m^3/min	As % of total
		Inland water bodies		
Locumba basin	2	No	73.7	36.8
Rímac basin	6	Yes	30.5	15.2
Moche basin	3	Yes	4.1	2.1
Majes basin	3	...	3.3	1.7
Pisco basin	2	...	2.5	1.2
Santa basin	5	Yes	2.5	1.2
Ocoña basin	2	...	0.5	0.3
Pativilca basin	1	Yes	0.4	0.2
		Into the sea		
Marcona	1	Yes	81.6	40.7
Ilo	4	No	1.4	0.7
Total	29	---	200.4	100.0

Source : UNEP, *Fuentes, niveles y efectos de la contaminación marina en el Pacífico Sudeste*, Informes y Estudios del Programa de Mares Regionales, No. 21, 1983, p. 92.

[a] It is not known what degree of treatment is provided or to what extent the information available is complete.

copper, gold, iron, lead, manganese, mercury, molybdenum, selenium, silver, tin, wolfram and zinc.

The basic reason for the significant contribution of mining to water pollution is the fact that, at best, only a minor part of its effluent receives treatment and this treatment is often only partial. As a result of inadequate treatment, many water bodies are polluted by mining industry wastes. One of the few exceptions to this rule is found in the Maipo river basin in the metropolitan region of Chile, where some 98% of the copper mining effluent was reported to receive some treatment (figure 19).[202]

In the Mantaro River in Peru, the concentration of metals, including heavy metals was reported to substantially exceed the norms established by the Water Law. The concentration of iron was 260 times in excess of the norm, and that of manganese 55 times in excess.[203] The Rímac River is considered to rank among the most polluted rivers of the continent. The pollution of this river is a matter of particular concern because water for 60% of the population of Lima is supplied from it. Its water contains varying amounts of potentially harmful elements, such as arsenic, cyanide, lead, chrome and selenium. Concentrations were reported to be approaching the norms established by the Regulations Governing the Sanitary Classification of Bodies of Water.[204]

On the other hand, mining does not appear to represent a serious threat to the water resources of the countries of Central America and the Caribbean. For example, it has been estimated that in Mexico the share of the extractive industry in overall water pollution leaving pollution caused by agriculture aside, is only 0.5%.[205] There are exceptions however, in Jamaica, the effluent of the bauxite-alumina industry is a major pollutant.[206]

In several bauxite-producing countries, wastes from the bauxite-alumina industry are dumped into coastal waters, endangering the marine environment, including fish life, and negatively affecting the use of the waters for recreational purposes.[207] The volume of waste produced in the Caribbean may seem insignificant in comparison with that produced by the mining industry of the South American countries, but on small islands, given their limited land and water resources, the negative impact of mining wastes may be much more pronounced.

ii) Petroleum production. Oil production is a further important source of water pollution in the region, both near points of extraction and in the case of transport by pipelines and ships. Historically, pollution related to petroleum production was significant only in a few Latin American and Caribbean countries, most notably

Trinidad and Tobago and Venezuela, where Lake Maracaibo and several other water bodies have suffered from oil pollution for many years. It has been estimated that in the basin of Lake Maracaibo, 15 minor oil spills occur each month on average.[208] The ecological balance of the lake has recently been reported to be "in mortal danger" due to pollution from oil spills and illegal dumping by oil tankers.[209]

The discovery of major petroleum deposits and the development of oil production in Argentina; southern Chile; the foothills of the Andes in Bolivia, Ecuador and Peru; the central Amazon basin; the South Atlantic and the Gulf of Mexico has considerably increased the number of water bodies exposed to such pollution (see annex 7). There are some specific cases of severe pollution. For example, according to a recent report, the Coatzacoalcos and Tonala Rivers in Mexico could be considered to have the most extreme levels of hydrocarbon pollution yet discovered in any of the world's coastal regions. In the Coatzacoalcos River, in particular, traces of fossil hydrocarbons were up to 10 times higher than the normal levels —an indication of the huge impact of the petroleum industry in the region.[210]

Petroleum pollution puts at risk not only inland water bodies but also coastal waters, which are polluted as a result of oil exploitation, the drilling of oil-wells and deliberate discharges from ships that ballast their oil tanks with sea water and following accidents. It has been estimated that the total ocean and sea spills of hydrocarbons in the region amount to more than 500 000 tons annually and that sea transport is responsible for some 28% of those spills.[211]

II. NON-POINT SOURCE WATER POLLUTION

The percolation, precipitation and unregulated run-off of already contaminated water into water bodies are the constituents of non-point source water pollution. Run-off from agricultural land and storm-water flows from urban areas are the most important of such sources in Latin America and the Caribbean.

A. RUN-OFF FROM AGRICULTURAL LAND

Run-off carries various pollutants in dissolved or suspended form from contaminated surfaces into water bodies. In the majority of

Latin American and Caribbean countries, agriculture is the prime source of contaminated run-off.

While the contamination of agricultural run-off caused by man-made substances is of relatively recent origin, contamination by suspended solids and salts has been common for a long time. The principal source of sediment is soil erosion, which, although it reaches its maximum in mountainous terrain, is also widespread in lowland areas. Increased amounts of sediment can result in substantial economic losses downstream. For example, in Honduras a rapid buildup of sediment has been reported to be reducing the capacity of the reservoir that supplies water to Tegucigalpa.[212] Increased sediment loads may also affect irrigation, navigation and other beneficial uses of water, but hydro-electricity generation suffers the most.

Irrigation drainage water can be a major source of pollution. While advanced methods of irrigation produce virtually no return flows thanks to their high water-application efficiency rates (up to 98%), they are not widely used in the region. In most countries of the region farmers still practise surface-gravity irrigation involving either the channelling of water through parallel furrows or the flooding of entire fields. The volume of return flow may be as much as one-third or more of the original flow. Irrigation drainage waters tend to be contaminated by varying amounts of suspended solids, dissolved salts or sodium, fertilizers, pesticides, insecticides, herbicides, pathogenic organisms (when organic fertilizers are used), and other substances.

On its way through the soil, irrigation water dissolves naturally- occurring salts and carries them to surface water bodies or groundwater aquifers, thereby increasing their salinity —or alkalinity, if sodium is dissolved. Salinity can render water unsuitable for other uses and adversely affect aquatic life. At the same time, the reuse of drainage water for irrigation is substantially accelerating the process of soil salinization or alkalinization which affects many areas in South America, Central America and Mexico. For example, on the coast of Peru about 34% the of land is estimated to suffer from salinization and drainage problems.[213]

A large and growing part of agricultural water pollution is caused by the use of fertilizers, pesticides, herbicides, insecticides and other chemical substances. Although the utilization of such substances continues to be low in Latin America and the Caribbean, in many cases the situation is aggravated by significant local abuses in application owing to a lack of knowledge of soil management techniques.[214]

1. Fertilizers

The consumption of fertilizers in Latin America and the Caribbean increased by approximately 97% between 1973 and 1985. In comparison with developed countries, however, Latin American and Caribbean countries still use a substantially smaller volume of fertilizer. In 1984 the consumption of fertilizers per hectare of farmland in Latin America amounted to only 7.9 kg (N, P_2O_5, K_20) compared with 142.7 kg in Europe and 45.8 kg in the United States. In some countries of the region, however (e.g., Cuba, Dominica, El Salvador, Saint Lucia, Suriname, and Trinidad and Tobago), the consumption of fertilizers is similar to that of developed countries.[215]

The increasing use of fertilizers poses the following problems for the region's water resources:

a) Both synthetic fertilizers and animal wastes are important sources of nutrients. The accumulation of nutrients in water bodies, especially lakes and reservoirs, can contribute to eutrophication.

b) The use of organic residues as fertilizers not only causes nitrate and phosphorus pollution, but can also be a source of pollution by pathogens, ammonia, etc., and increased BOD. In zones of intensive cattle breeding, animal wastes, even if they are not used as fertilizers, can still harm water resources.

c) The increasing use of nitrogenous and phosphate fertilizers is leading to high nitrate and phosphorus concentrations, which pose potential health hazards.

2. Pesticides, herbicides, insecticides and other chemical substances

These materials can be transported to water bodies either indirectly —through percolation, precipitation, or run-off— or directly when used to control aquatic organisms, pests and weeds.

Two characteristics of these materials make them a major hazard for water resources:

a) They are both toxic to aquatic life and humans; this is particularly true of organophosphates, which tend to penetrate more deeply into the soil than organochlorinated compounds, thus increasing the threat to deeper aquifers.[216]

b) They are frequently non-degradable or only degrade very slowly; for example, the toxicity of organic chlorinated compounds decreases by only 50% over 10 years. As a result, they not only tend to accumulate but also are prone to food chain concentration (i.e., they become concentrated instead of dispersed with each link in the food chain).

In general, the Latin American and Caribbean countries use a substantially lower level of agrotoxic chemicals in their agriculture than do developed countries. Nevertheless, although the total volume of consumption is not known, pesticide imports increased by almost half between 1971-1973 and 1983-1985.[217]

Furthermore, pesticide consumption substantially exceeds the regional average in some areas. For example, in certain areas of the Pacific coast in Central America, 80 kilograms of pesticides are applied per hectare of cotton, which is one of the highest figures in the world, while El Salvador was reported to have used at least 20% of the world's total parathion output in a recent year.[218] Even where the use of pesticides and other similar products is not so intensive their application can still pose problems locally for water resource management:

a) The Latin American and Caribbean countries place relatively few restrictions on the use of agricultural chemicals. For example, from the list of agricultural chemicals in the United Nations publication *Consolidated list of products whose consumption and/or sale have been banned, withdrawn, severely restricted or not approved by governments*, some 20%-25% are subject to any restrictions in Latin American and Caribbean countries, and the majority of these restrictions are of recent origin (see annex 8).[219]

As a result, the countries of the region continue to employ chemical substances whose use is either restricted or no longer permitted in countries with more stringent environmental legislation (see table 19).[220] An example is afforded by the pesticide dibromochloropropane (DBCP), which has been banned in many countries and is classified by the World Health Organization (WHO) as extremely hazardous; nevertheless, this pesticide has been reported to be in use in Costa Rica, Ecuador, Honduras and possibly in Colombia and Panama.[221]

Although organic chlorinated compounds such as DDT and aldrin —which have been in use for more than 30 years and are still being used today— play a key role in water pollution in the region, they are giving way to others, such as phosphates and carbamates. In Peru, for example, 55% of all imported insecticides in 1979, were organic chlorinated compounds and, prior to 1977, DDT and mercury containing fungicides were used without restriction.[222] DDT use is still widespread in several countries of Central America.[223]

b) The improper application and misuse of these potentially dangerous materials or non-observance of existing legal limitations on their use frequently result in a high number of pesticide poisonings;

Table 19

LATIN AMERICA AND THE CARIBBEAN: PESTICIDES USED IN OR SOLD TO AGRICULTURE WHOSE CONSUMPTION AND/OR SALE HAVE BEEN BANNED, WITHDRAWN, SEVERELY RESTRICTED OR NOT APPROVED BY GOVERNMENTS [a]

Product	Country	Year [b]	100 kg
ALDRIN [c]	Argentina	1984	5 832
	Ecuador	1984	689
	El Salvador	1979/81	432
	Guatemala	1979/81	1 470
	Guyana	1979/81	22
	Mexico	1985	1 000
	Suriname	1979/81	630
	Uruguay	1985	126
ARSENICALS	Uruguay	1979/81	26
BHC	Argentina	1984	60
	El Salvador	1979/81	12
	Mexico	1985	2 500
	Suriname	1979/81	961
DDT	Argentina	1979/81	6
	Ecuador	1984	4 000
	El Salvador	1979/81	1 269
	Guatemala	1979/81	12 570
	Mexico	1985	3 000
	Suriname	1979/81	33
LINDANE	Argentina	1984	1 725
	Guatemala	1979/81	11
	Honduras	1986	1 371
	Mexico	1985	150
	Uruguay	1985	5
PARATHION	Argentina	1984	9 234
	Ecuador	1984	584

Table 19 (concl.)

Product	Country	Year [b]	100 kg
	El Salvador	1979/81	12 144
	Guatemala	1979/81	905
	Honduras	1986	1 360
	Mexico	1985	46 000
	Uruguay	1985	140
TOXAPHENE	El Salvador	1979/81	5 252
	Mexico	1985	6 000
2,4-D	Argentina	1984	12 024
	Ecuador	1984	8 684
	Honduras	1985	28
	Mexico	1985	14 000
	Suriname	1979/81	525
	Uruguay	1985	1 424
2,4,5-T	Argentina	1979/81	117
	El Salvador	1979/81	168
	Guatemala	1979/81	124
	Mexico	1984	500
	Suriname	1979/81	200

Source : FAO, *1987 FAO Production Yearbook*, vol. 41, Rome, 1988, pp. 9-10 and 119-127; and United Nations, *Consolidated list of products whose consumption and/or sale have been banned, withdrawn, severely restricted or not approved by governments*, ST/ESA/192, 1987, Second issue.

[a] Data refer generally to quantities of pesticides used in, or sold to agriculture. They are shown in terms of active ingredients, except for Ecuador and Guatemala, where data refer to formulation weight. Formulation weight usually includes active ingredients plus diluents and adjuvants.

[b] The latest year for which consumption data have been available.

[c] Consumption figures are for aldrin and similar insecticides.

it has been reported that about 1 800 pesticides poisonings per 600 000 population occur in Central America annually, in comparison with only 1 per 600 000 a year in the United States. In a recent five-year period approximately 17 000 pesticide poisonings were medically certified in Guatemala and El Salvador alone.[224] One of the contributing factors is that in some countries there is no centralized authority for the administration of the trade, use and application of pesticides.

3. The regional situation

Little information exists on the impact of chemicals used in agriculture on the water resources of the region. Brazil, however, with a consumption level of some 150 000 tons annually, ranks among the top five countries in the world in terms of pesticide use. Moreover, several of the products still in use in Brazil, including aldrin, eldrin, ethilic parathion, heptachlor and lindane, have been banned or restricted in a number of European countries and the United States.[225]

Agriculture-related water pollution has been identified in several South American countries, including Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru and Venezuela, as well as in several water bodies in Central American and Caribbean countries.

Apart from the agriculture-related water pollution caused by fertilizers and agrotoxic chemicals, abstractions from rivers for irrigation and other purposes can alter the annual hydrograph and thereby indirectly affect water quality. Under certain circumstances, this may lead to saline water penetration into deltas or estuaries and the problem may be aggravated if abstractions are made during periods of low flow. Saline intrusion is particularly noticeable in the rivers of tropical countries where there is a large difference between maximum and minimum flows. This phenomenon has been observed in the River Guayas, Ecuador, where saltwater intrusion has precluded the river's use as a source of water supply for the city of Guayaquil during periods of low flow.[226]

Abstractions of water reduce the amount of water available for the dilution of domestic and industrial effluents and thus give rise to a corresponding increase in the intensity of pollution.[227] This can be particularly significant in the case of industries characterized by a seasonal pattern of production, such as sugar or coffee processing, whose peak periods of activity coincide with major abstractions and low flows.

B. STORM-WATER RUN-OFF

In Latin America and the Caribbean the use of separate storm drainage systems is generally limited. In the majority of the urban areas, most storm-water run-off is channeled into the natural drainage system. A proportion, however, of storm-water enters the sanitary sewerage systems. As much of the region lies in tropical and sub-tropical zones characterized by heavy rainfall, the amount of storm-water run-off from urbanized areas can be significant (see table 20). The pollutant potential of urban storm-water run-off is related to its BOD strength, suspended solids content, organic and inorganic (particularly phosphorus, nitrogen and lead) pollutant load and bacterial contamination.[228] A comparison of the chemical characteristics of storm-water run-off and those of other urban effluents shows that they are, to a certain extent, comparable sources of water pollution. Given the possible volumes of storm-water run-off in major urban areas it can be an important source of pollution.

When collected in combined sewerage systems, storm-water run-off may also result in the hydraulic overloading of these systems and of sewage treatment plants. This may aggravate pre-existing pollution problems and cause the contamination of urban areas. Overloading of sewerage systems and treatment plants by storm-water run-off represents a particularly serious problem in the region because many Latin American cities lack storm sewer networks. For example, storm-water run-off has been reported to have caused damage to water supply and sewerage systems in several cities of Honduras. This was accompanied by contamination problems.[229] In Santiago, Chile, rainwater periodically finds its way into the sewerage network and causes the collector chambers in some sectors of the city to overflow.[230]

C. PERCOLATION OF POLLUTED WATER INTO GROUNDWATER

Seepage from waste dumps, septic tanks, sewerage systems, oil and chemical spills and the use of water for irrigation, watering, street-flushing, etc., can result in the slow percolation of polluted water into groundwater and its subsequent contamination. Eventually, such contaminated groundwater will find its way into rivers, lakes and reservoirs.

Table 20

ESTIMATED AVERAGE POTENTIAL STORM-WATER RUN-OFF FROM 1 SQUARE KILOMETRE, IN SELECTED LATIN AMERICAN CITIES

Country	City	Estimated average storm-water run-off $m^3/min/km^2$	
		Annual average	Rainiest month
1. Argentina	Buenos Aires	1.1	1.5
2. Bolivia	La Paz	0.6	1.6
3. Brazil	Rio de Janeiro	1.2	1.8
4. Chile	Santiago	0.4	1.1
5. Colombia	Bogotá	1.1	2.0
6. Costa Rica	San José	2.1	4.4
7. Ecuador	Guayaquil	1.1	3.4
8. El Salvador	San Salvador	2.0	4.4
9. Honduras	Tegucigalpa	1.0	2.6
10. Mexico	Mexico City	0.9	2.2
11. Nicaragua	Managua	1.4	3.9
12. Paraguay	Asunción	1.5	2.1
13. Peru	Lima	0.03	0.08
14. Suriname	Paramaribo	2.5	4.3
15. Uruguay	Montevideo	1.2	1.4
16. Venezuela	Caracas	0.9	1.5

Source : Estimated on the basis of information from FAO, *Datos agroclimatológicos de América Latina y el Caribe*, Rome, 1985; and on the assumption that storm-water run-off represents 60% of the original precipitation.

Groundwater pollution is a cause of particular concern in Latin America and the Caribbean because many cities, including several large metropolitan centres, such as Mexico City and Havana, as well as the extensive arid and semi-arid areas in much of the region and thousands of rural communities rely on springs and wells for drinking water and irrigation. Much of the rural dispersed population uses such for drinking water and latrines. The bad siting of latrines commonly leads to contamination of the well.

The percolation of water contaminated by fertilizers and toxic agrochemicals does not represent, however, such an acute problem in the majority of Latin American and Caribbean countries as in more developed regions. This is due both to the substantially lower utilization of these materials in the region's agriculture and to the predominant climatic and soil characteristics. According to recent assessments, in tropical climates certain soils have a lower risk of nitrate leaching than do similar areas under temperate conditions.[231]

One particular aspect of the percolation problem is the intrusion of saltwater as a result of the growing use of groundwater from coastal aquifers for irrigation as well as for other purposes. This phenomenon can be seen in many coastal areas of the region, particularly in islands of the West Indies where intensive irrigated agriculture is based on groundwater utilization. In Caribbean countries groundwater is also frequently used for water supply. Other examples are to be found in Argentina, where saline water intrusion has been reported to threaten coastal areas near the city of Mar del Plata and to have caused the salinization of some aquifers in the area of Buenos Aires.[232] Saltwater intrusion has also been reported in El Salvador and Mexico.

The percolation of polluted water from septic tanks, sewerage systems and waste dumps is also a significant source of groundwater contamination in the region:

a) The percolation of water contaminated by human wastes from septic tanks, which are widely used in the region, and from sewerage systems, which are usually poorly maintained, is a major source of groundwater contamination, particularly by microorganisms and nitrates. In several cities as much as 50% of the water supply is lost through leakage (for example, distribution losses in Buenos Aires, Argentina, are reported to amount to 4.7 - 9.5 m^3/sec).[233] Although similar information is not available in regard to sewerage systems, there is no reason to believe that leakage does not occur.

Cases of groundwater pollution have been reported in many large metropolitan areas (e.g., in Buenos Aires,[234] Santiago,[235] and Mexico City). In Mexico City, in the neighbourhood of Xochimilco, it has been necessary to close several wells because of an excessive concentration of nitrates in the water, possibly due to pollution from the Chalco Channel, which transports urban sewage.[236] Also in Mexico, the dumping of waste water in the subsoil of the city of Mérida is reported to have resulted in the severe pollution of groundwater aquifers of the city, and some of its outlying areas.[237]

b) The seepage of toxic chemicals from industrial liquid waste dumps and solid waste dumps containing household garbage is a further threat to the region's groundwater resources. It has been estimated that total urban solid waste production in Latin America and the Caribbean was 160 000 tons a day in 1984 and that the amount of such waste that is generated has been growing at the rate of 4% annually since 1980.[238] The total potential regional leachate from this volume of solid waste may reach 5 - 6 m^3/sec, with an expected increase to 9 - 10 m^3/sec by the year 2000.[239] Given that leachate from sanitary landfills usually contains high concentrations of both organic and ammoniacal nitrates, copper, zinc, nickel, phosphates, sulfates, chlorates, CO_2, SO_3, etc. and is characterized by high pH and extremely high BOD (in the range of 20 000-30 000 mg/l),[240] the risk to the region's groundwater resources is obvious. It should be noted that, in general, in Latin American countries industrial wastes are dumped together with domestic wastes. Of the countries for which information is available, only Brazil and Mexico have begun to use technologies for industrial waste disposal that take environmental protection needs into consideration.[241]

An equally important and related problem in many countries of the region is the direct tipping of solid wastes into water bodies. For example, it has been estimated that in Colombia about 25% of solid wastes are disposed of by tipping them into bodies of water [242] (some 184 000 tons are dumped every year in the basin of the Medellín River alone).[243] In Ecuador, the dumping of some 3 300 tons a year of solid wastes has been reported to have impaired the water quality of the Tomebamba and Machánagara rivers.[244] Direct tipping of solid wastes into bodies of water has also been reported in Haiti and the Netherlands Antilles.[245] In Guanabara Bay, Brazil, most of the solid wastes are dumped at the edge of the bay, with the city of Rio de Janeiro alone dumping over 3 000 tons daily.[246] Household solid wastes have also been reported to contribute to water pollution problems in the Caracas Metropolitan Region in Venezuela.[247]

D. PRECIPITATION OF POLLUTED WATER

Precipitation tends to absorb certain air pollutants, gases, particles, pathogens, etc. and to carry them directly or indirectly, through run-off or percolation, into water bodies. For a long time this was presumed to be an insignificant source of water pollution in comparison with other non-point sources. In recent years, however, as a result of research on acid rain and toxic metals, the precipitation of polluted water and pollution loading from dry atmospheric deposition are receiving increasing attention.[248] Polluted precipitation may represent a particular problem in many Caribbean countries where rainwater is an important source of drinking water.

There is virtually no information on the relationship between air and water pollution in Latin America and the Caribbean. The characteristics of predominantly airborne pollutants found in the region are such as to suggest that many of them can be transferred to water bodies from the air by rain. One of the few areas of the region for which information on the chemical characteristics of precipitation is available is Cerro Verde in El Salvador (see table 21). A few cases of pollution through precipitation have been reported in the highly industrialized southeastern section of Brazil, where some soils have become acidic as a result of acid rains. Brazil is particularly vulnerable in this respect because in a number of areas (e.g., the Amazon basin) the soil is naturally acidic.[249] In Chile, acidic precipitations has been detected in the Santiago Metropolitan Region, as well as in the localities of Caletones, Catemu, Nos, Puchuncavi and Ventanas, and precipitation contaminated by heavy metals and industrial elements in regions V and VIII.[250] In addition to cases of acidic precipitation, at least one instance of seawater pollution by gases originating from fish processing plants has been reported in Peru.[251]

III. THE IMPACT OF WATER POLLUTION ON HUMAN HEALTH AND WELFARE

Untreated human wastes are generally considered to be the most dangerous environmental threat to human health. In Latin America and the Caribbean despite the advance made in recent years diseases transmitted through water contaminated by human waste are still very common, although deaths from diarrhoeic diseases have decreased dramatically in the last 20 years. Deaths from such diseases remain, however, the first or second principal cause of death in children under 1 year old and from 1 to 6 years old in those countries with the highest rates of infant mortality.[252]

Table 21

PRECIPITATION CHEMISTRY MONITORING, 1975-1982, IN EL SALVADOR (CERRO VERDE)

Characteristics	1975/1976	1977/1978	1979/1980
1. Average annual pH			
- El Salvador, Cerro Verde	4.7	5.5	5.1
- average for locations in the United States and Canada	5.3[a]	5.4[b]	5.5[c]
2. Average annual concentration of sulfate (milligrams per litre)			
- El Salvador, Cerro Verde	n/a	0.54	0.70
- average for locations in the United States and Canada	1.20[a]	1.04[b]	1.04[c]
3. Average annual concentration of nitrate (milligrams per litre)			
- El Salvador, Cerro Verde	n/a	0.03	0.36
- average for locations in the United States and Canada	0.38[d]	0.45[e]	0.44[c]

Source : World Resources Institute and International Institute for Environment and Development, *World Resources 1986*, p. 324.

[a] Average for 17 locations.
[b] Average for 22 locations.
[c] Average for 23 locations.
[d] Average for 16 locations.
[e] Average for 21 locations.
n/a = Not available.

A. HUMAN WASTES AND HUMAN HEALTH

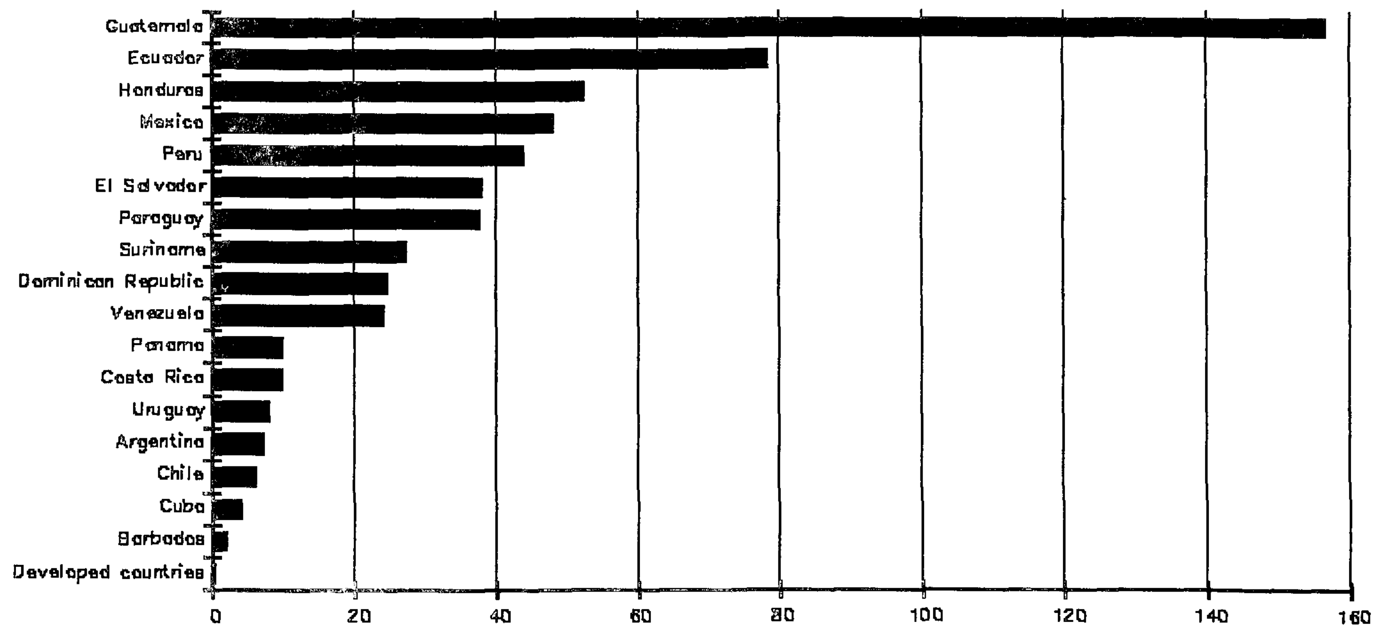
Water pollution by domestic wastes, organic matter and certain other substances plays a major role in the transmission of various diseases, including cholera, typhoid fever, dysentery, other intestinal infectious diseases, etc. The mechanisms of disease transmission vary. Initially, causative organisms find their way into water bodies either as part of domestic sewage and the effluent of certain industries (particularly meat packing and processing) or from other sources since they are present in the environment. Water polluted by organics provides a good breeding ground for microorganisms, which survive and/or reproduce there until they enter the human body. Direct transmission can occur through drinking water: in 1985, 14% of the urban population of the region and 55% of the rural population still lacked a protected source of drinking water. Even when a supply of drinking water is available, the water is not always of adequate quality. The sale of bottled water in urban areas reflects a general concern with the quality of the public water supply. Moreover, the contamination of water bodies used as a source of drinking water increases the cost of treatment.

In addition to the direct contamination of drinking water there are other routes of transmission. Certain diseases are transmitted by bathing in polluted water. Indirect transmission can occur through contaminated agricultural products and fish, the bite of an insect vector that breeds in polluted water, etc.

Undeniably, the pollution of surface waters by domestic sewage poses serious health problems for the population, particularly in urban areas. It is generally agreed that both the high rate of infant mortality and the incidence of various intestinal infectious diseases, which are markedly higher in the region than in developed countries (figure 22), can be, at least partially attributed to the biological pollution of water bodies by human wastes. For example, according to a study carried out by the School of Public Health of the University of Antioquia to determine the health benefits of controlling the pollution of the Medellín River (Colombia), 0.3% of all deaths in the city, 28.8% of deaths from enteritis and diarrhoea, and 71.4% of deaths from tuberculosis could be avoided. Considering the medical expenses involved, days off work, production losses, etc., the public health benefits were estimated to amount to US$3 600 000 (1982).[253] In Chile, although only 30% of the national population lives in Santiago, the city accounts for 60% of all cases of typhoid fever.[254] Both Medellín and Santiago are characterized by a high level of bacteriological contamination of adjacent water bodies due to

Figure 22

DEATHS FROM TYPHOID FEVER AND OTHER INTESTINAL INFECTIOUS DISEASES, RATES PER 100 000 POPULATION



Source: WHO, information for various recent years.

a lack of sewage treatment. In Mexico, salmonella poisoning and other gastric problems have been reported to be above the national average among the 1 500 000 people living near the heavily-polluted Coatzacoalcos River.[255] The segment of the population which is most affected by such problems is usually composed of low-income groups that lacks safe water supply, sewerage facilities or medical services.

B. THE CONSEQUENCES OF THE USE OF POLLUTED WATER FOR IRRIGATION

A problem particular to point-source water pollution of urban origin is the use of already contaminated water for irrigation. This frequently occurs in areas where large urban centres are located in zones of irrigated agriculture and where untreated waste flows are returned to watercourses which are subsequently used for irrigation. One motivation for the use of waste water for irrigation is the fact that the nutrients in it may be regarded as cheap fertilizers capable of substantially improving crop yields.

The use of untreated waste water for irrigation —a practice which is widespread in the countries of the region— may give rise to serious sanitary problems, particularly if adequate sanitation and treatment standards are not maintained. Both pathogens and heavy metals, apart from having direct harmful effects on crops and soils, are able to enter the food chain along with other pollutants. For example, reports indicate that in Santiago, Chile, the risk involved in consuming raw vegetables originating from nearby areas may be as much as five times higher than that associated with vegetables grown in coastal areas.[256] In Mexico City, after little or no treatment, waste waters, including those contaminated by heavy metals and toxic organic compounds, have been used for irrigation. As a result, contaminants have been discovered in vegetables and other crops which give cause for concern about long-term health risks.[257] In Argentina, the pollution of water used for irrigation has also been identified in the Grande and Primero Rivers.[258] In Cuba, water from the Almendares River and Arroyo Grande was reportedly being used for the irrigation of vegetables in spite of the level of microbacteriological contamination.[259]

C. RECREATION AND HEALTH

Offensive smells, floating materials (particularly sewage solids) and certain other pollutants including high suspended sediments, dyes, etc., can create aesthetically repellent conditions for recreational uses of water and reduce its visual appeal. Even more importantly elevated levels of bacteriological contamination and, to a lesser extent, other types of pollution can render water bodies unsuitable for recreational use. This is of particular concern in those countries where tourism is an important source of foreign exchange and employment. Several tourist areas in the region are affected to various degrees by water pollution, including such popular resorts as Guanabara Bay in Brazil,[260] Viña del Mar in Chile and Cartagena in Colombia.[261]

In general, recreation is a much neglected use of water in the region hardly considered in the process of water management. The available information suggests, however, that pollution in recreational areas is a serious problem. This is particularly the case as the recreational use of water is very popular and it is concentrated in those water bodies closest to the large metropolitan areas. Many of these are increasingly contaminated by domestic sewage and industrial effluents.

IV. WATER POLLUTION CONTROL

The increasing contamination of surface and groundwater has prompted the governments of many Latin American and Caribbean countries to adopt measures for combating water pollution. These include laws designed to control water pollution, water quality monitoring and more widespread treatment of waste water and incipient attempts to control some non-point pollution.

A. LAWS AIMED AT CONTROLLING WATER POLLUTION

Most countries have begun to develop a body of law providing for water pollution control. Many countries now have the necessary basic legislation to empower public agencies to take steps to control water pollution. In addition, several countries have incorporated provisions relating to environmental protection in their laws and, in a few, a guarantee of a clean environment is even contained in their national constitutions (for example, the Constitutions of Chile (article 19), Cuba, Guyana (articles 25-36), Panama (article 114) and Peru (article 123)).

Colombia, Mexico and Venezuela can be cited as having the most comprehensive legislation and the strongest institutions for environmental management.[262] In particular, Colombia possesses one of the most comprehensive bodies of environmental law, the National Renewable Natural Resources and Environmental Protection Code (decree 2811, dated December 18, 1974). This legislation, which has been referred to as the first "omni-comprehensive law in the world", deals with all elements of the environment in an integrated form.[263] Furthermore, water quality and pollution control in Colombia are also subject to the Sanitary Code, which was framed in 1945 and revised in 1979. In 1984 a section on water quality was added to the Code, and this was followed by pollution control regulations.[264] Other countries in the region have made fewer advances in institutionalizing the consideration of the environment in resource management.

In the majority of countries, regulations relating to water pollution control are incorporated not only in their environmental law, but also in the laws governing different spheres of water resource management and use. For example, in Antigua and Barbuda the public health laws prohibit the pollution of watercourses and drains, while in Jamaica the Mining Act contains some safeguards against pollution.[265] In many countries there are specific laws, sometimes dating back several decades, regulating pollution originating from major sources of contamination. One example is Venezuela, which adopted a law to control pollution from hydrocarbons as long ago as 1936.[266]

In most cases the legislation specifically prohibits the discharge of untreated or inadequately treated effluent into bodies of water. For example, in Ecuador the Environmental Pollution Prevention and Control Act (decree 374, dated June 21, 1976) prohibits the discharge of untreated wastes into sewerage networks, lakes, rivers, etc., as well as the infiltration into the ground of waste water containing contaminants harmful to human health, fauna, flora or property.[267] In Cuba, Law Number 33, which deals with environmental protection and the rational use of natural resources (dated February 12, 1981), requires an adequate treatment of waste before its discharge into the environment.[268]

Licensing the construction and operation of potentially contaminating industrial plants and processes is a relatively frequent means of controlling discharges. Such provisions are, for example, incorporated in the respective laws of Brazil, Colombia and Mexico.[269] In Brazil, the existing legislation delegates the authority to grant licenses to the state governments and in certain cases, to the municipalities. However, the granting of licenses for some activities, such as the operation of nuclear plants, is the exclusive prerogative of the Federal Government.[270] In Cuba, all agencies that invest in the water resources sector must obtain the prior approval of the Water Economy Institute for each project in respect of the nature and disposal of effluents, the source of the water and the volume to be used.[271] In the Dominican Republic, a concession is required for the use of water in industry and mining. Such concessions remain in effect so long as the activity in question does not infringe the law by polluting the water with substances harmful to health, vegetation or to fish and fisheries.[272] The legislation of several countries (including Colombia, Cuba, Ecuador and Mexico) provides for the establishment of emissions standards governing the physical, chemical and biological composition of effluents.[273] In Ecuador, the Environmental Pollution Prevention and Control Act authorizes the Ministry of Health to establish the degree of treatment that effluents should receive.[274] Legislation in several countries —including Brazil, Colombia, Cuba and Mexico— provides for restrictive zoning. In some cases such laws refer to the protection of groundwater wells, upper watersheds, etc.[275] For example, in Montserrat a specific ban on activities likely to pollute surface water bodies is in effect within areas over which the Government has authority for water resource conservation and protection purposes.[276] In Cuba, the location of activities whose effluents, even when treated, pose potential risks of contamination is prohibited in the catchment areas of water supply sources for population and industry.[277]

Pollution control legislation usually specifies the measures to be used to ensure compliance with the established norms. In Latin America and the Caribbean these provisions cover a wide spectrum, ranging from economic measures (such as direct effluent charges, fines and incentives for the development and construction of water treatment facilities) to administrative measures (such as the temporary or definite prohibition of pollution-causing activities or plants). In the case of pollution of, or in close proximity to, the sources of public water supplies, sanctions may even include imprisonment. As for economic measures, Brazil and Colombia, for example, have explicitly adopted the "polluter pays" principle in their legislation.[278]

The legislation of Brazil, Colombia and Mexico provides for educational measures and the promotion of public awareness as a means of combating pollution.[279] Very strong penalties for offenders —including plant closures— have been recently introduced in Colombia.[280]

Several countries of the region have adopted the requirement that all new projects be evaluated in terms of their impact on the environment, including possible water pollution. Although environmental impact evaluation provisions have not yet become widespread, they do figure in the legislation of Brazil, Colombia, Ecuador and Mexico, among other countries.[281] For example, in Colombia under the National Renewable Natural Resources and Environmental Protection Code, every person planning to undertake any activity likely to cause environmental degradation is required to submit a statement concerning the projected environmental risks involved. At the same time, an ecological and environmental study is necessary prior to any activity that may cause a serious degree of deterioration of renewable natural resources or the environment.[282]

Few Latin American and Caribbean countries have comprehensive restrictions on the use of chemicals in agriculture. Of the countries for which information is available, Argentina, Colombia and Ecuador seem to have the most developed legislation (see annex 8).[283] In Mexico a new environmental law regulating the sale and use of toxic substances was to go into effect in 1988.[284] The legislation of several countries also contains provisions regulating the use of effluents for irrigation. For example, in Mexico, the Federal Environmental Protection Act provides that urban sewage may be used in industry and agriculture only if it is treated in accordance with the standards set by the Department of Urban Development and Ecology in co-ordination with the Department of Agriculture and Water Resources and the Department of Health and Welfare.[285]

The apparent contradiction between the widespread occurrence of water pollution and the existence of sophisticated control legislation in many Latin American and Caribbean countries seems to arise from the fact that the implementation of such legislation is usually weak. In some cases regulations may not have been promulgated, while in others, even when appropriate norms do exist, their application is frequently hampered by the dispersion of legislative authority, the failure to set out the provisions of such regulations in sufficient detail, or both.

Positive steps have been taken, however, particularly in the more industrialized countries of the region, towards the serious control of polluting industries and the enforcement of requirements that effluent be treated. The same trend can be seen in regard to other sources of water pollution as well, particularly the treatment of municipal wastes. Evidence of this is provided by the adoption of policies on pollution abatement and control. Examples include the announcement in 1984 of a nationwide plan for the control of water pollution in Argentina,[286] the preparation of a number of studies on polluted water bodies, and the taking of specific measures to control emissions (e.g., a water pollution control programme for the city of Bogota, Colombia, has resulted in the installation of effluent treatment plants in dozens of factories).[287] Studies on the behaviour of water bodies for the purpose of planning pollution control measures have been undertaken in Havana Bay (Cuba), in Guanabara Bay (Brazil), off Montevideo (Uruguay) and Valparaíso (Chile), in the basin of the Yaracuy River (Venezuela), and elsewhere. As a result of sustained efforts in this connection, the decline in water quality in the State of Sao Paulo, Brazil, has been reported to be levelling off and, in some cases, even to be improving; some areas which had reached critical levels have been reduced to point problems and fish are re-entering certain rivers.

B. WATER QUALITY MONITORING

Even the best water pollution law is almost certain to fall short of its objectives if it is not supported by an adequate water quality monitoring network. Legislation in Colombia, Costa Rica and Cuba specifically provides for the collection, classification and dissemination of information related to the environment and its conservation. On-going monitoring of the environment and of its state of preservation is provided for by the laws of Brazil, Colombia, Cuba and Mexico.[288]

An efficient water quality monitoring network should be able to measure the quality of potable water, of surface and groundwater *in situ*, and of effluent, as well as being capable of tracing specific pollutants to their sources. Of these three types of water quality monitoring, the control of drinking-water quality is the most highly developed in the region, and all the countries have laboratories for its analysis. In general, potable water control is best organized in the larger cities.[289] It should be noted, however, that some countries continue to experience problems in relation to the quality of their drinking water.

The measurement of surface and groundwater quality, particularly in the most densely populated, urbanized and industrialized river basins, has progressed considerably in the region, and especially in Argentina, Brazil, Chile and Mexico. In these countries systematic studies have been made of the pollution problems of many water bodies.

Most municipal and industrial effluents are discharged into water bodies without any prior treatment and consequently, the monitoring of waste water quality is limited. It is only practised only at the few existing effluent treatment facilities as a means of assessing the treatment process.

Thus, few countries have, as yet, adequate water quality monitoring networks. According to a United Nations survey, in 1983 the majority of Latin American and Caribbean countries considered their water quality observation networks to be insufficient, although reliable, and most of the countries had plans to expand existing networks.[290] Nonetheless, several countries do have relatively well developed national water quality monitoring networks. In Brazil, the National Water and Electrical Power Department (DNAEE) has been surveying water quality parameters since 1973 and, since 1978 the water quality network has been operating with Brazilian-made equipment.[291] This constitutes a notable achievement since many countries of the region must import monitoring equipment and have subsequently experienced difficulties related to servicing and spare parts. In Chile, the Bureau of Water Resources not only operates two networks used in the monitoring of water quality, but is also developing a modern computerized system for the storage and retrieval of hydro-meteorological information.[292] In Cuba, the National Network of Control Laboratories, comprising 37 Health and Epidemiology Laboratories and the National Institute of Health, Epidemiology and Microbiology (INHEM), monitors water quality, while INHEM regulates and supervises the Network's laboratories.[293] In Panama, the Institute of Water Resources and Electrification (IRHE) initiated a national water quality monitoring programme in 1975 and now maintains a network of some 200 water quality stations. Data validity is continuously checked by means of analytical quality control systems.[294] The use of remote-sensing technologies for water quality monitoring is being investigated in a number of countries.

Assistance has been provided in connection with much of the work being done in the field of water quality monitoring by the programmes of the Pan American Center for Sanitary Engineering and Environmental Science (CEPIS) of the Pan American Health Organization (PAHO) and by the United Nations Environment Programme (UNEP).

C. TECHNOLOGICAL ADVANCES IN WATER POLLUTION CONTROL

One of the main difficulties that Latin American and Caribbean countries face in improving water pollution control is the high cost of waste water treatment. Moreover, such local factors as the lack of qualified personnel, social and climatic particularities, the specific chemical composition of sewage and industrial effluent, etc., hinder the direct application of water treatment technologies developed in other regions. In several countries of the region, efforts are being made to develop relatively simple and low-cost waste treatment techniques, such as stabilization (facultative, maturation or anaerobic) ponds, and methods based on the use of locally available products. Some countries (e.g., Brazil, Colombia, Costa Rica and Mexico) have even incorporated provisions into their legislation concerning the development of appropriate technologies as a means of environmental protection.[295]

1. Waste treatment

Stabilization ponds are widely recognized as being a low-cost, highly efficient method of sewage treatment, particularly in tropical and subtropical regions. These two features make them very attractive in Latin America and the Caribbean, and stabilization pond research has been carried out in several countries. For example, research at the Federal University of Paraiba in Brazil has demonstrated that stabilization ponds substantially reduce BOD and suspended solids and are especially effective in removing excreted pathogens; in fact, the results of this techniques were found to be several thousands of percentage points better in this respect than conventional treatment systems.[296]

Extensive research in the field of industrial and domestic sewage treatment is being carried out by CETESB in Brazil and has included the study of simple aeration systems, criteria for settling ponds, oxidation systems, etc. Waste water treatment-related research is also being conducted in other states of Brazil as well. For example, the Water and Sewerage Company of the State of Parana (Companhia de Agua e Esgotos do Parana - SANEPAR) has been actively studying anaerobic digestors for the conversion of biodegradable pollutants into methane gas and agricultural fertilizer, the utilization of methane gas obtained from sewage gas as an automotive fuel, the use of coagulants other than alum, and other subjects.[297]

In several countries research has been accompanied by efforts to introduce simple and low-cost waste treatment techniques in smaller towns and villages. One example of such an initiative is the Proyecto de Desarrollo Tecnológico de Instituciones de Agua Potable y Alcantarillado in Peru, which has been undertaken with the assistance of CEPIS.

Another positive development is that some countries have begun to promote and encourage waste water reuse. This is particularly the case in areas characterized not only by water pollution problems but also by acute water shortages. Sewage reuse is of particular interest for the region's agriculture since it is known to be rich in nutrients, mainly nitrogen and phosphorus, and —after adequate treatment— represents a valuable and low-cost agricultural input. Undoubtedly, the most notable example in the field of waste water reuse is to be found in the Federal District of Mexico, where recycled waste water accounts for some 4% (155 500 m^3/day) of current water use (mainly in recreational lakes and in the irrigation of public parks). According to existing plans, by the year 2000 about 17% of the District's waste water will be reused to supply some 12% of the projected water demand.[298] The Mexico scheme is also considered to represent the largest-scale use of raw sewage for irrigation in the world. Currently, approximately 82 000 ha are irrigated by raw sewage around the capital, and there are plans to convert a further 128 000 ha of land elsewhere in the country to sewage-fed irrigation. Before expanding the project, a detailed study on the health risks involved is to be carried out.[299] In Peru a research project has been undertaken at San Juan de Miraflores (near Lima) since 1961 to investigate the productive reuse of sewage waste water for irrigation; currently 500 ha are being irrigated by this means, and there are plans to use this method on another 1 300 ha in the future.[300]

One important step forward has been the establishment, under the leadership of CEPIS, of a regional information system on the environmental health aspects of water management through the Pan American Network for Information and Documentation in Sanitary Engineering and Environmental Sciences (REPIDISCA).

A great deal of research is being done on the use of local products for waste treatment. For example, in Bolivia, with assistance from UNESCO, the utilization of *Schocnoplectus tatora* seeds and of aquatic weeds for water purification has been studied.[301] Other countries have investigated bacterial leaching. This technology, apart from permitting the extraction of metals from low-grade ores and concentrates, provides the possibility of using mine waste dumps productively while also curbing pollution, since the tailings undergo a chemical change as part of this process which renders them harmless. Industrial applications of this technology are in use at Cerro de Pasco in Peru and at Cananea in Mexico, and other projects are under consideration. In addition, research has been reported to be underway in Chile with a view to improving the bacterial action.[302] Another achievement has been the utilization of the large quantities of waste products generated by the coffee processing industry in Costa Rica for animal feed. At present, about one-third of the coffee-processing waste generated in Costa Rica is being used in the production of an energy-rich and nutritious animal food.[303]

2. Biological control of agricultural pests

Research into means of reducing contamination by agrotoxic chemicals has led to the exploration of alternative methods of pest control, including biological techniques —although these are not yet in widespread use. An exception is Mexico, where in 1987 an estimated 765 000 ha of farmland (60% more than in 1986) were reported to be protected by biological means of pest control.[304] Biological control has also been successfully used in Costa Rica on banana plantations. Other applications, which have resulted in a substantial reduction of insecticide and pesticide use, have been undertaken in Brazil and Nicaragua. In Brazil, impressive advances have been made in the application of alternative methods of pest control in the production of soybeans; participating farmers have reportedly achieved a reduction of insecticide use of up to 80-90%.[305]

3. Human resource development

One significant obstacle to better pollution control is the lack of appropriately qualified personnel. This lack tends to be aggravated by the low salaries prevailing in many national civil services and the consequent high staff turnover rates. There is in the region, however, much attention being given to the education and training of the required personnel.

Most countries have some form of training related to pollution control and waste disposal and there are institutions in some countries, as well as international organizations that offer training on a regionwide basis. For example, courses are offered at the Escuela Regional de Ingeniería Sanitaria (ERIS) at the University of San Carlos in Guatemala, at the Pan American Centre for Sanitary

Engineering (CEPIS) of the Pan American Health Organization in Lima, Peru and at the Inter-American Centre for Integrated Land and Water Development (CIDIAT) in Merida, Venezuela. Some national courses are open to students from all Latin American and Caribbean countries. Equally important is the fact that several of these organizations are actively engaged in waste water treatment research.

D. THE WORK OF INTERNATIONAL ORGANIZATIONS

Various international and regional organizations are working in the field of water pollution control. Their activities focus on the preparation of studies (both at office level and field reports), training courses, the promotion of horizontal co-operation among competent national organizations and the preparation of manuals and dissemination of methods. PAHO and its sanitary engineering centre, CEPIS, are the most active organizations. Their recent water pollution control-related activities and projects have included: the monitoring and control of pollution in Cartagena Bay and tributary areas, in Colombia; the design of a manual concerning marine outfalls; advisory services concerning water pollution and the application of mathematical models of water quality in relation to the Bogotá River (Colombia), Chimbote (Peru) and the Asososca lagoon (Nicaragua); the transfer of water from the Mantaro River (Peru); a regional programme for the improvement of the quality of water for human consumption; a regional programme on appropriate technology for the collection, treatment and final disposal of waste water and excreta in medium-sized, small and dispersed rural communities in Peru; and a regional project on simplified methodologies for studies of eutrophication in tropical lakes.

The international and regional banks, particularly the Inter-American Development Bank (IDB), support investments in pollution control. In 1979 the IDB adopted a policy on environmental management with a view to preventing its projects from having adverse environmental impacts. In 1983, it established the Environmental Management Committee, which is responsible for ensuring the environmental review of all projects financed by the Bank and for promoting an understanding of environmental issues. Apart from helping its member countries with a variety of projects, such as those involving preventive measures to avoid the discharge of contaminating effluent into bodies of water, the IDB also stresses institution building, the training of personnel in environmental technology, and the identification and solution of environmental problems. An example of the IDB's special efforts in the field of water pollution control is afforded by two loans totalling US$46 400 000 which were approved in 1986 for a project to expand and improve the water and sewerage system of Tijuana, Mexico. This project involves extensive measures to treat and dispose of sewage effluents so that both the city and adjacent beaches will be protected from pollution.[306] In 1970, the World Bank, for its part, established the office which later became the Office of Environmental and Scientific Affairs. This office has the responsibility of examining all projects for their possible consequences for the environment and of incorporating suitable measures for the preservation or mitigation of seriously detrimental effects.[307] Recently the World Bank has created environmental units in its regional divisions, as well as a central environmental department,[308] and is taking other steps with the aim of increasing its ability to assist developing countries to manage their natural resources on a sound environmental basis. In addition to the pollution-control components in its projects, the World Bank, in co-operation with other organizations, has prepared and issued guidelines and manuals, conducted training activities, provided technical assistance, etc. One example of the Bank's activities in the field of water pollution control is the US$60 000 000 loan that it approved in fiscal year 1986 for the development of a water-supply and sewerage system in Santiago, Chile, which includes a pollution-abatement component.[309]

V. CONCLUSIONS

During the past decade the countries of Latin America and the Caribbean have made some progress towards remedying the pollution problems resulting from their increasing use of water resources for waste disposal and transport. The region continues to face, however, a steady decline in water quality in many bodies of water, and efforts to arrest the decline are still no more than incipient.

The report provides clear evidence that the contamination of water resources continues to increase. Control measures are weak, the financial resources for investment in waste treatment are insufficient and, in general, the preservation of water quality remains a secondary consideration. There are too many water bodies in the region in which the decline in quality has reached critical proportions, although there is some evidence of a public reaction to this situation and the issue is beginning to figure more prominently on the political agendas of governments.

Despite the gains that have been made, far more remains to be done if even the most glaring instances of biological pollution are to be controlled, as indicated by the critical level of intestinal and other water-related diseases among children and adults. Moreover, if controls are not initiated, the problem will surely grow worse as the expansion of water-supply and sewerage coverage leads to a greater use of the water resources of the region for the transport of wastes.

Notes

[1] World Bank, *Report on World Development 1983.*

[2] Miguel S. Wionczek, "La aportación de la política hidráulica entre 1925 y 1970 a la actual crisis agrícola mexicana", *Comercio Exterior*, vol. 32, No. 4, Mexico, April 1982, pp. 394-409.

[3] Subsecretaría de Planeación, Secretaría de Recursos Hidráulicos, "Plan Nacional Hidráulico 1975", Mexico City, July 1976.

[4] Instituto Nacional de Ciencia y Técnica Hídricas (INCYTH), Centro de Economía, Legislación y Administración del Agua, various publications, 1973-1983, Mendoza, Argentina.

[5] Axel Dourojeanni, *La planificación para el desarrollo, aprovechamiento, y manejo de los recursos hídricos*, CDA-24, ECLAC, Santiago, Chile, November 1980.

[6] Fernando González Villarreal, "Central Planning in Water Resources Development", United Nations publication, *Water Resources Planning. Experiences in a National and Regional Context*, TCD/SEM.80/1, New York, 1980.

[7] Sandro Petricione, "Water Management Planning: The Regional and Central Approach", United Nations publication, *Water Resources Planning. Experiences in a National and Regional Context*, TCD/SEM.80/1, New York, 1980.

[8] United Nations, "The Demand for Water: Procedures and Methodologies for Projecting Water Demands in the Context of Regional and National Planning", *Natural Resources/Water Series No. 3*, Doc. ST/ESA/38, New York, 1976; John C. Kammerer, "Estimated Demand of Water for Different Purposes", *Water for Human Consumption*, Report of the IVth World Congress of I.W.R.A., 3 to 12 September 1982, Argentina.

[9] Institute for Land Reclamation and Improvement (ILRI), *Framework for Regional Planning in Developing Countries*, No. 26, Wageningen, The Netherlands, J. M. van Staveren and D. V. W. M. van Dusseldorp (eds.), 1983.

[10] United Nations, Department of Economic and Social Affairs, "Integrated River Basin Development", *Report of a Panel of Experts*, New York, 1970.

[11] Gunther Schramm, "Integrated River Basin Planning in a Holistic Universe", *Natural Resources Journal*, vol. 20, October 1980.

[12] Comisión del Plan Nacional Hidráulico, Secretaría de Agricultura y Recursos Hidráulicos, *Plan Nacional Hidráulico 1981*, Mexico, D.F., March 1981. It should be noted, however, that this plan is a second version; the first was published around 1957. This means that Mexico began the planning of its water resources long before the United Nations Water Conference.

[13] Comisión del Plan Nacional de Aprovechamiento de los Recursos Hidráulicos (COPLANARH), *Plan Nacional de Aprovechamiento de los Recursos Hidráulicos*, vol. 1, *El Plan*, Caracas, 1972.

[14] Comisión Multisectorial del Plan Nacional de Ordenamiento de los Recursos Hidráulicos, *Plan Nacional de Ordenamiento de los Recursos Hidráulicos. Bases Técnicas y Económicas para su Formulación*, Lima, 1977.

[15] United Nations, *El Salvador: Plan maestro de desarrollo y aprovechamiento de los recursos hídricos. Conclusiones y recomendaciones del Proyecto*, New York, 1983.

[16] Dirección de Planificación del Instituto Nacional Ecuatoriano de Recursos Hidráulicos (INERHI), "Marco general para la elaboración del Plan Nacional Hidráulico", *Documento PNRH 6*, Quito, August 1981.

[17] Departamento Nacional de Planeación, *Plan nacional de aguas. Términos de referencia*, Bogotá, January 1982.

[18] Secretaría Técnica del Consejo Superior de Planificación Económica (CONSUPLANE), *Plan Nacional de Recursos Hídricos 1979-1983*, Tegucigalpa.

[19] UNDP, "Jamaica: National Water Resources Development Master Plan", project document, New York, January 1984.

[20] Instituto de Cooperación para la Agricultura/Instituto Nacional de Recursos Hidráulicos, "Lineamientos para un Plan Nacional de Recursos Hidráulicos y Recursos Naturales relacionados para la República Dominicana", document prepared by Professor Warren A. Hall, Santo Domingo, March 1981.

[21] In general the term "ordenamiento" would seem to be the most appropriate in Spanish since it does not limit the plan to water use, as does the term "aprovechamiento", but permits the inclusion of other aspects associated with conservation, preservation and protection of the environment and prevention and control of adverse natural phenomena such as floods, droughts and the like. The term

"aprovechamiento" however, is also considered adequate if it is implicitly assumed that it refers to a rational use that includes the aspects mentioned in "ordenamiento". The term "desarrollo" is not considered necessary or even suitable for inclusion since natural resources such as water are not "desarrollados" *per se* but rather utilized for the purposes of development. It is apparently a literal translation of the phrase "Water Resource Development" commonly used in English. The omission of a qualifying term is also somewhat undesirable since there are no "resource plans" but plans to do something with resources, although in practice this is quite understood. As regards the terms "agua", "hidráulico" and "hídrico", the dictionary of the Real Academia de la Lengua states that the term "hidráulico" has a connotation of "arte de conducir, contener, elevar y aprovechar las aguas" and would therefore exclude the idea of preservation, conservation and protection of the quality and quantity of water (environmental aspects) and would rather be focused on fluid mechanics. For this reason, as a variant of the term "agua" and to convey the idea of value to society, Latin America commonly uses the term "Recursos Hídricos" although this does not figure in the official dictionary and is also a translation adapted from the English phrase "Water Resources".

[22] COMPLANORH, "Plan nacional de ordenamiento de los recursos hidráulicos", Lima, August 1977, p. XI.

[23] COPLANARH, "Plan nacional de aprovechamiento de los recursos hidráulicos", Caracas, 1972.

[24] Departamento Nacional de Planeación, "Plan nacional de aguas. Términos de referencia", Bogotá, January 1982.

[25] UNDP, "San Salvador: Plan maestro de desarrollo y aprovechamiento de los recursos hídricos", project document, San Salvador, March 1979.

[26] Comisión Nacional del Plan Hidráulico, *Plan Nacional hidráulico 1981*, Mexico City, March 1981.

[27] *Ibid.*

[28] The documents relating to the Cuban plan are not for publication.

[29] UNDP, "Jamaica: National Water Resources Development Master Plan", project document, New York, January 1984.

[30] Instituto Nacional de Planificación del Peru (INP), *Plan Nacional de Ordenamiento de los Recursos Hidráulicos. Bases Técnicas y Económicas para su Formulación*, COMPLANORH, Lima, August 1977.

[31] Ministry of Agriculture and Food, "Análisis sistemático de la problemática para el desarrollo, uso y conservación de los recursos agua y suelo", Lima, 1979.

[32] *Ibid.*, "Plan nacional de rehabilitación de tierras costeras - PLANREHATIC", project financed by the World Bank, Lima, 1979.

[33] This is undoubtedly the weakest aspect of the plans for water resource management in the region and likewise the key factor that needs improvement.

[34] Universidad del Pacífico, *Estudio sobre las perspectivas y alcances del proyecto Majes-Siquas*, Centro de Investigación, Lima, 15 February 1980.

[35] Frequently this happens because the State directs the action of the public sectors towards "priority development areas" without specifying or establishing interinstitutional co-ordination mechanisms for working simultaneously in the areas selected.

[36] ECLAC, "Proyecto regional de interconexión eléctrica el Istmo Centroamericano", Mexico City, March 1979.

[37] Ministry of Energy and Mines of Peru, *Evaluación del potencial hidroeléctrico nacional*, 19 volumes, Lima, 1974. The "HEC-4" (originating in the Hydrologic Engineering Center, of the United States Engineering Corps in California) is a monthly autoregressive stochastic model, multivaried, which generates synthetic sequences of a hydrological variable, and fills information gaps by employing correlations with other stations.

[38] Hydrocomp, "Microprocessors in Simulation", *Newsletter Mountain View*, California, April 1983.

[39] Argentina: Ministry of Economy, "Plan nacional de equipamiento para los sistemas de generación y transmisión de energía eléctrica, período 1979-2000. Descripción metodológica. Módulos utilizados. Producción hidroenergética", Buenos Aires, September 1979, p. 105.

[40] INERHI, "Experiencias en planificación hidráulica en el Ecuador", written communication, Quito, July 1983.

[41] IPEA-IPLAN-CPS, "SME: energía eléctrica na década dos 70", Brasilia, March 1982.

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ANNEXES

Annex 1

LATIN AMERICA AND THE CARIBBEAN: INFORMATION ON ON WATER-RELATED NATURAL DISASTERS, 1979-1987

Table 1

WATER-RELATED DISASTERS, BY SUB-REGION AND TYPE OF DISASTER

Sub-region	Type of disaster	Number
Central America and the Caribbean		
	All disasters	91
	Drought	20
	Flood	26
	Land/mudslide	1
	Windstorm	44
South America	All disasters	127
	Drought	8
	Flood	80
	Land/mudslide	32
	Windstorm	7
Total	All disasters	218
	Drought	28
	Flood [a/]	106
	Land/mudslide	33
	Windstorm	51

[a/] According to available information, of the 106 floods at least 21 were accompanied by land/mudslides.

Table 2

NUMBER OF DEAD, INJURED AND MISSING, BY SUB-REGION AND TYPE OF DISASTER

Type of disaster	Central America and the Caribbean	South America	Events for which data have been available as percentage of events of similar type included in table 1
Drought	0	20	3.57
Flood	3 133	5 719	69.81
Land/mudslide	10	31 752	90.91
Windstorm	16 570	425	56.86
Total	19 713	37 916	61.47

Note: The above information has been obtained from the analysis of data on water-related natural disasters in Latin American and Caribbean countries between 1979 and 1987. It has been gathered from a great variety of sources ranging from specialized publications of competent international and national organizations to newspaper and magazine articles. Unfortunately, it has not always been possible to verify whether the information is true to fact or not. This annex does not include all water-related natural disasters that took place in the region between 1979 and 1987, and information available on each of them is not necessarily directly comparable.

Annex 1 (concl.)

Table 3

DAMAGE CAUSED, BY TYPE OF DISASTER (constant 1980 US dollars)

Type of disaster	Estimated damage (millions constant US dollars at 1980 prices)	(%)	Events for which data have been available as percentage of events of similar type included in table 1
Drought	123.3	1.3	7.14
Flood	5 416.8	58.4	20.75
Land/mudslide	321.4	3.5	6.06
Windstorm	3 407.8	36.8	25.49
Total	9 269.4	100.0	17.89

Note: The reported amount of damage has been inflated/deflated by the United States Capital Equipment Price Index.

Annex 2

LATIN AMERICA AND THE CARIBBEAN:
EMERGENCY PLANS AND DISASTER LEGISLATION

Country	Emergency plans	Disaster legislation
Antigua and Barbuda	National Disaster Preparedness Plan	n/a
Argentina	Programas Nacionales de Preparativos para casos de desastre	- DECRETO LEY No. 6250/58, sobre organización del país para la Defensa Civil. - LEYES DE MINISTERIOS Nos. 22.520 del 19/12/81, 22.641 del 13/09/82 y 23.023 del 06/12/83, establecen la competencia del Ministerio de Salud y Acción Social (en los casos de emergencias sociales que requerían el auxilio del Estado Nacional).
Bahamas	- National Disaster Plan (in project) - Operational emergency plans (at various levels)	n/a
Barbados	Mobilization Procedures of the Central Emergency Relief Organization (CERO) (annually updated)	- ACT "to make exceptional provision for the protection of the community in case of emergency"
Belize	- Hurricane Plan, 1986 amended version - Hurricane Plans (11) at level of Central Emergency Organization's 11 National Committees	n/a
Bolivia	Plan Nacional de Emergencia, 1980	- DECRETO SUPREMO No. 19386, 17 de Enero de 1983: Creación del Sistema de Defensa Civil. (Law on Civil Defence being drafted).
Brazil	Plano Nacional de Defesa contra as Calamidades (under consideration)	- DECRETO No. 66204, 13.02.1970, (FUNCAP) - Re. Financial aspects of emergency planning. - DECRETO No. 67347, 05.10.1970, (GEACAP) - Re. Special assessment group. - LAWS for each State of the Federation on which Civil Defence is based (federal level).
Chile	- Plan Nacional de Emergencia de 1977 - Bianual Directivas Nacionales de Emergencia	- DECRETO-LEY No. 369, de 1974, (Creación de la Oficina de Emergencia del Ministerio del Interior (ONEMI) - "Orgánico de ONEMI y su Reglamento"). - DECRETO SUPREMO No. 155, de 1977, aprueba el Plan Nacional de Emergencia. - DECRETO SUPREMO No. 509, de 28 de Abril de 1983. Reglamento para la aplicación del Decreto-Ley No. 369, de 1974.
Colombia	Sistema Nacional de Prevención y Manejo de Desastres o Calamidades Publicas	- LEY No. 142, de 1937, que fija los Derechos y Deberes de la Cruz Roja como Instituto Nacional de Asistencia y Caridad Pública. - LEY No. 49, de 1948, por la cual se provee la Creación del "Socorro Nacional en Caso de Calamidad Pública".

Country	Emergency plans	Disaster legislation
continued Colombia		- DECRETO-LEY No. 2341, de 1971, por el cual se organiza la Defensa Civil. - LEY No. 9A, de 1979: Código Sanitario Nacional. Título VIII - "Desastres". - DECRETO No. 3489, de 1982, por el cual se reglamenta el Título VIII de la Ley No. 9A de 1979 y el Decreto-Ley No. 2341 de 1971 en cuanto a Desastres. - DECRETO-LEY No. 1547, de 1984: Creación del Fondo Nacional de Calamidades; Normas para su Organización y Funcionamiento. - DECRETO No. 2068, de 1984, por el cual se modifican algunas disposiciones del Decreto-Ley No. 2341 de 1971, Orgánico de la Defensa Civil Colombiana, y se dictan otras Disposiciones. - PROYECTO DE LEY por el cual se crea y organiza el sistema nacional de Prevención y Manejo de Desastres o Calamidades Públicas.
Costa Rica	Documento Básico para elaboración del Plan Nacional de Emergencia 1976	- LEY No. 4374, de 14 de Agosto de 1969. "Ley Nacional de Emergencia". Creación de la Comisión Nacional de Emergencia. - DECRETO EJECUTIVO No. 4020-T, de 13 de Agosto de 1974. "Reglamento de Emergencias Nacionales". - DECRETO No. 17031-P-MOPT, de 16 de Mayo de 1986 (Modificaciones de la legislación sobre la Comisión Nacional de Emergencia). - DECRETO No. 17275-P-MOPT, de 31 de Octubre de 1986.
Cuba	- Plan for Protection against Hurricanes and Heavy Rains - Plan for Protection against Catastrophes	- LAW No. 1194, of 11 July 1966, on Civil Defence
Dominica (Commonwealth of)	*Disaster Emergency Plan* 1981 (1986: draft of revised version)	- *EMERGENCY POWERS ORDINANCE of 16 July 1951*
Dominican Republic	National Disaster Plan 1986	- LEY No. 257, of June 1966. Establishment of an Office of Civil Defence. Provision for the Preparation of a Plan and General Programme for Civil Defence in the whole territory.
Ecuador	Plan Nacional de Defensa Civil	- DECRETO EJECUTIVO No. 1463, de 8 de Enero de 1986. Creación de la Unidad Ejecutora de Obras Emergentes (Executing Unit for Emergencies). - DECRETO No. 436, de 28 de Julio de 1980, aprueba el Plan Nacional de Defensa Civil.
El Salvador	- Plan General de Emergencia "ESPERANZA-84" (Comité de Emergencia Nacional, 1984) - Sectorial and other emergency plans, manuals, etc., 1984-86.	- DECRETO LEGISLATIVO No. 498, de 8 de Abril de 1976. Creación del Sistema de Defensa Civil como parte integrante de la Defensa Nacional. - LEY DE EMERGENCIA NACIONAL para Auxilio a la Población Civil. - REGLAMENTO de la Ley de Emergencia Nacional para Auxilio a la Población Civil.

Annex 2 (cont.2)

Country	Emergency plans	Disaster legislation
Grenada	- National Disaster Plan (completed in 1983) - Disaster Preparedness Programme.	n/a
Guatemala	Plan de Trabajo 1986 del Comité Nacional de Emergencia	- ACUERDO GUBERNATIVO, 8 de Septiembre de 1969. Creación del Comité Nacional de Emergencia. - ACUERDO GUBERNATIVO, 28 de Septiembre de 1971. Ratificación con carácter de Permanente - REGLAMENTO GENERAL del Comité Nacional de Emergencia, Agosto de 1981.
Guyana	National Disaster Preparedness Plan (draft) 1985	n/a
Haiti	Projet de Plan ORSEC Cyclone - 1985	- LOI portant création et organisation de l'Organisation Pré-Désastre et de Secours (OPDES), 1983.
Honduras	Emergency Measures 1981 (according to Instruction No. 1 of Consejo Permanente de Emergencia Nacional (COPEN))	- DECRETO LEY No. 33 de 13 de Marzo de 1973 y sus respectivas Reformas de fecha 30 de Marzo de 1975. Creación del COPEN. - INSTRUCTIVO PC No. 01 de 14 de Agosto de 1981, de Procedimientos para tomar medidas en situaciones de emergencia causadas por desastres naturales (COPEN).
Jamaica	- Emergency Operations National Disaster Plan 1980 - Preparedness Plans for individual Parishes and Communities and for each hazard	- GOVERNMENT DECISION, dated July 1980, to establish an Office of Disaster Preparedness and Emergency Relief Co-ordination (ODP).
Mexico	Programa de Protección Civil	- DECRETO por el que se aprueban las Bases para el Establecimiento del Sistema Nacional de Protección Civil, 1986. (Diario Oficial, Estados Unidos Mexicanos, Mexico D.F., Martes 6 de Mayo de 1986).
Nicaragua	National Disaster Plan (in preparation, 1985)	- DECRETO No. 113 de 5 de Abril de 1973. Emergencia Nacional.
Panama	Plan de Protección Civil 1982	- LEY No. 22 de 15 de Noviembre de 1982. Creación del Sistema de Protección Civil para Casos de Desastre (SINAPROC). - RESUELTO No. 682 de 13 de Noviembre de 1984. Creación del Nuevo Comité ad hoc, presidido por S.E. el Ministro de Gobierno y Justicia.
Paraguay	n/a	- LEY No. 832 de 1980. "Ley de la Organización General de las Fuerzas Armadas" (Art. 3 - Defensa Civil). - ESTATUTOS del Consejo Nacional de Entidades de Beneficencia (CONEB), de 1983.

Annex 2 (concl.)

Country	Emergency plans	Disaster legislation
Peru	Plan de Operaciones de Emergencia (de Defensa Civil) 1983	- DECRETO LEY No. 19338 de 10 de Marzo de 1972. Lay de Creación del Sistema de Defensa Civil. - DECRETO SUPREMO No. 017-72-IN de 25 de Julio de 1972. Reglamento de Defensa Civil - DIRECTIVA No. 03 DC/SE (4) - Formulación del Plan de Operaciones de Emergencia de Defensa Civil, 1983. - RESOLUCION DIRECTORAL No. 0003-87-IN-DC/SE, de 6 de Febrero de 1987, nombran Comision encargada de recibir donaciones en dinero y especie para ser destinados a damnificados.
Saint Christopher and Nevis	(New) Disaster Plan 1984 *(draft)*	n/a
Saint Lucia	National Disaster Plan (last revised version) 1985	n/a
Saint Vincent and the Grenadines	National Disaster Plan 1986	n/a
Suriname	n/a	n/a
Trinidad and Tobago	Basic System for Disaster Preparedness	n/a
Uruguay	n/a	- LEY No. 15.688, de 11 de Noviembre de 1984 - Ley de Defensa Civil. - Ley No. 15.808, de 7 de Abril de 1986 - Se modifica la Ley Orgánica de las Fuerzas Armadas.
Venezuela	- Programas de la Comisión Nacional de Defensa Civil - Plan Regional de Defensa Civil (Plan TIPO, 1974)	- DECRETO No. 702 de 7 de Septiembre de 1971. Creación de la Comisión Nacional de Defensa Civil. - DECRETO No. 533 de 12 de Noviembre de 1974. Comisión Nacional de Defensa Civil. - DECRETO No. 231 de 10 de Agosto de 1979. Reorganización de la Comisión Nacional de Defensa Civil ("La CNDC organizará una Oficina Coordinadora de D.C.").

Source: Office of the United Nations Disaster Relief Co-ordinator (UNDRO), List of national officials responsible for the management of disasters and other emergencies, emergency plans and disaster legislation, 1987.

n/a = Information has not been available or there are no emergency plans and/or disaster legislation. This list is not necessarily exhaustive.

Annex 3

LATIN AMERICA AND THE CARIBBEAN:
NATIONAL ORGANIZATIONS IN THE FIELD OF DISASTER MANAGEMENT

Country	National organizations in the field of disaster management
Anguilla	- National Disaster Committee under the chairmanship of the Governor - Permanent Secretary/Co-ordinator of Disaster Preparedness, Cabinet Secretary, Chief Minister's Office
Antigua and Barbuda	- National Disaster Committee under the chairmanship of the Honourable Minister of Health - National Disaster Co-ordinator, Ministry of Home Affairs
Argentina	- Dirección Nacional de Defensa Civil, Ministerio de Defensa - Dirección Nacional de Emergencias Sociales (DINES), Ministerio de Salud y Acción Social
Bahamas	- Civil Defense Department - National Disaster Co-ordinator, Prime Minister's Office
Barbados	Central Emergency Relief Organization (CERO), Prime Minister's Office
Belize	Central Emergency Organization, Office of the Premier
Bermuda	Police Headquarters
Bolivia	Dirección Nacional de Defensa Civil, Ministerio de Defensa Nacional
Brazil	- Civil Defense, Ministry of the Interior - Grupo Especial para Asuntos de Calamidades (GEACAP), Ministry of the Interior - Fondo Especial para Calamidades Publicas (FUNCAP), Ministry of the Interior - Defensa Civil do Estado de Sao Paulo
British Virgin Islands	National Disaster Co-ordinator, Assistant Secretary to Deputy Governor
Cayman Islands	Deputy Commissioner of Police
Chile	Oficina Nacional de Emergencia (ONEMI), Ministerio del Interior
Colombia	- Dirección Nacional de la Defensa Civil - National Co-ordinator on Disaster Prevention and Management, General Secretary, President's Office
Costa Rica	- Civil Defence - National Health-Sector Emergency Commission (CONESS)
Cuba	Oficina de Desastres, Defensa Civil
Dominica (Commonwealth of)	National Emergency Planning Organization, Office of the Prime Minister

Country	National organizations in the field of disaster management
Dominican Republic	- Civil Defence Ministry - National Director of Emergencies, Secretariat of Public Health and Social Welfare
Ecuador	- Dirección Nacional de Defensa Civil - Dirección de la Unidad Ejecutora de Obras Emergentes
El Salvador	Comité de Emergencia Nacional (COEN), Ministerio del Interior
Grenada	- Office of Disaster Preparedness, Ministry of Information and National Security - Parliamentary Election Officer/National Disaster Co-ordinator, Office of the Prime Minister
Guatemala	Comité Nacional de Emergencia (CONE)
Guyana	Civil Defence Commission chaired by the Minister of Health and Public Welfare
Haiti	Organisation Pré-Désastre et de Secours (OPDES), Ministère de la Santé Publique et de la Population
Honduras	Consejo Permanente de Emergencia Nacional (COPEN)
Jamaica	Office of Disaster Preparedness and Emergency Relief Co-ordination
Martinique	Direction Departementale de la Securite Civile
Mexico	- Sistema Nacional de Protección Civil - Subsecretaría de Asentamientos Humanos, Dirección General de Prevención y Atención de Emergencias Urbanas (SAHOP) - Centre Medical de l'Universite Autonome (UNAM) - Fondo Nacional para Actividades Sociales (FONAPAS)
Montserrat	Government Information Officer, National Disaster Co-ordinator
Nicaragua	- Comité Nacional de Emergencia Frente al Desastre - Oficina de Defensa Civil Nacional, Ministerio de Defensa
Panama	Sistema Nacional de Protección Civil para Casos de Desastres (SINAPROC), Ministerio de Gobierno y Justicia
Paraguay	- Civil Defence Organization, Ministry of the Interior - Consejo Nacional de Entidades de Beneficencia (CONEB)
Peru	- Comité Nacional de Defensa Civil - Division of Emergencies and Catastrophes, Department of Epidemiology, Ministry of Health
Puerto Rico	Oficina de Defensa Civil, Oficina del Gobernador

Annex 3 (concl.)

Country	National organizations in the field of disaster management
Saint Christopher and Nevis	Permanent Secretary and Federal Disaster Co-ordinator, Ministry of Home Affairs
Saint Lucia	National Disaster Co-ordinator, Prime Minister's Office
Saint Vincent and the Grenadines	- Central Emergency Relief Organization - National Disaster Co-ordinator, Ministry of Housing and Labor
Suriname	Bureau of Public Health
Trinidad and Tobago	National Emergency Relief Organization, Ministry of National Security
Turks and Caicos	National Disaster Co-ordinator, Under-Secretary, Chief Minister's Office
Uruguay	- Servicio General de Defensa Civil, Ministerio de Defensa Nacional - Comité de Asistencia
Venezuela	- Dirección Nacional de Defensa Civil, Ministerio de Relaciones Interiores - FUNDASOCIAL
US Virgin Islands	Civil Defense and Emergency Services, Office of the Governor

Source: United Nations Office of the Disaster Relief Co-ordinator (UNDRO), 1986; and UNDRO, List of national officials responsible for the management of disasters and other emergencies, emergency plans and disaster legislation, 1987.

Note: This list is not necessarily exhaustive.

Annex 4

LIST OF ECLAC DOCUMENTS IN THE FIELD OF NATURAL DISASTER DAMAGE ASSESSMENT

1. Informe sobre los daños y repercusiones del terremoto de la Ciudad de Managua en la economía nicaragüense (CEPAL/MEX/73/Nic.1; E/CN.12/AC.64/2/Rev.1), 1973.

2. Informe sobre los daños causados en Antigua y Barbuda por el sismo del 8 de octubre de 1974 y sus repercusiones (E/CEPAL/1001-(ESP).

3. Informe sobre los daños y repercusiones del huracán Fifí en la economía hondureña (E/CEPAL/AC.67/2/Rev.1), 1974.

4. Evaluación de los daños causados por el temporal en Granada y repercusiones para los programas de desarrollo económico (E/CEPAL/CDCC/9), 1975.

5. Daños causados por el terremoto de Guatemala y sus repercusiones sobre el desarrollo económico y social del país (CEPAL/MEX/76/Guat.1), 1976.

6. Report on the Effect of Hurricane "David" on the Island of Dominica (E/CEPAL/G.1099), 1979.

7. República Dominicana: Repercusiones de los huracanes David y Frederico sobre la economía y las condiciones sociales (E/CEPAL/G.1098)/Rev.1).

8. Guatemala: Repercusiones de los fenómenos meteorológicos ocurridos en 1982 sobre la situación económica del país (E/CEPAL/MEX/L.31), 1982.

9. El Salvador: Los desastres naturales de 1982 y sus repercusiones sobre el desarrollo económico y social (E/CEPAL/MEX/1982/L.30), 1982.

10. Nicaragua: Las inundaciones de mayo de 1982 y sus repercusiones sobre el desarrollo económico y social del país (E/CEPAL/G.1206), 1982.

11. The Natural Disasters of 1982-1983 in Bolivia, Ecuador and Peru (E/CEPAL/G.1274), 1983.

12. Ecuador: Evaluación de los efectos de las inundaciones de 1982/1983 sobre el desarrollo económico y social (E/CEPAL/G.1240), 1983.

13. Repercusiones de los fenómenos meteorológicos de 1982 sobre el Desarrollo Económico y Social de Nicaragua (E/CEPAL/MEX/1983/L.1), 1983.

14. Damage Caused by the Mexican Earthquake and its Repercussions upon the Country's Economy (LC/G.1367), 1985.

15. The 1986 San Salvador Earthquake: Damage, Repercussions and Assistance Required (LC/G.1443) plus addendum containing Project Profiles (LC/G.1443/Add.1), 1986.

16. Economic and Social Consequences of Recent, Major Natural Disasters in Latin America and the Caribbean: A Need for Prevention and Planning, 1986.

17. The Natural Disaster of March 1987 in Ecuador and its Impact on Social and Economic Development (LC/G.1465), 1987.

Annex 5

LATIN AMERICA AND THE CARIBBEAN: ESTIMATES OF DOMESTIC SEWAGE OUTFLOW AND COMPOSITION FOR CITIES WITH 100 000 INHABITANTS OR MORE IN 1980, BY MAJOR HYDROGRAPHIC BASINS AND COUNTRIES a/

a/ The presence or absence of waste water treatment facilities has not been taken into consideration.

These estimates are based on:

i) Population in 1980 (Latin American Center, *Statistical Abstract of Latin America*, University of California, Los Angeles, various recent years; and other sources).

ii) Sewerage service (house connections) coverage of the urban population for the country as a whole (1980); in the cases where this information has not been available, coverage by sewerage and excreta disposal services was used (WHO, *The International Drinking Water Supply and Sanitation Decade-Review of National Baseline Data (as at December 1980)*, Offset Publication No. 85; PAHO/WHO, Environmental Health Program, *International Drinking Water Supply and Sanitation Decade*, Regional Progress Report, Environmental series No. 6, p. 18; and Osvaldo Montero Ojeda, Instituto de Hidroeconomía, *El Programa cubano para el abastecimiento de agua y saneamiento para poblaciones de bajos ingresos*, Seminario Regional sobre Agua Potable y Saneamiento para Grupos de Bajo Ingreso en Comunidades Rurales y Urbano-marginales, Recife, 1988, Documento No. 14, p. 3);

iii) The level of consumption is taken to be 200 litres per capita per day;

iv) The following conversion factors are applied:
DBO_5 - 19.7 kg/inh./year,
phosphorus - 0.4 kg/inh./year,
nitrogen - 3.3 kg/inh./year,
suspended solids - 20.0 kg/inh./year
(United Nations, ECLAC, *Desarrollo industrial: generación y manejo de los residuos* (LC/R.602(Sem.41/6), 28 August 1987, p. 52).

Latin America and the Caribbean: Estimates of Domestic Sewage Outflow and Composition for Cities with 100 000 Inhabitants or more in 1980, by Major Hydrographic Basins and Countries

Cities by major hydrographic basins, countries, and recipient water bodies		DOMESTIC SEWAGE OUTFLOWS (m3/sec)	DBO (Ton/year)	PHOSPHORUS (Ton/year)	NITROGEN (Ton/year)	SUSPENDED SOLIDS (Ton/year)
BASIN: Amazon						
Bolivia						
Cochabamba	Rocha	0.14	1 180	24	198	1 197
La Paz	Choqueyapu	0.43	3 682	75	617	3 738
Santa Cruz	Pirai	0.18	1 534	31	257	1 558
	Subtotal	0.75	6 396	130	1 071	6 493
Brazil						
Belem	Marajo Bay	0.56	4 779	97	801	4 852
Campo Grande	Aripuana	0.21	1 783	36	299	1 810
Manaos	Amazon	0.45	3 865	78	647	3 924
	Subtotal	1.23	10 427	212	1 747	10 586
Peru						
Cuzco	Vilcanota	0.23	2 000	41	335	2 030
Huancayo	Negro	0.21	1 787	36	299	1 814
Iquitos	Amazon	0.23	1 937	39	324	1 966
	Subtotal	0.67	5 724	116	959	5 811
	TOTAL FOR BASIN	2.65	22 546	458	3 777	22 890
BASIN: Brazil, north-east						
Brazil						
Campina Grande	Paraiba	0.16	1 401	28	235	1 422
Caruaru	Ipojuca	0.10	868	18	145	881
Fortaleza	Atlantic Ocean	0.48	4 090	83	685	4 152
Joao Pessoa	Atlantic Ocean	0.22	1 831	37	307	1 859
Juazeiro do Norte	Salgado	0.09	790	16	132	802
Maceio	Atlantic Ocean	0.28	2 373	48	398	2 409
Natal	Atlantic Ocean	0.28	2 374	48	398	2 410
Olinda	Capibaribe	0.20	1 679	34	281	1 705
Recife	Atlantic Ocean	0.88	7 465	152	1 251	7 579
Sáo Luis	San Marcos Bay	0.14	1 150	23	193	1 168
Teresina	Parnaiba	0.25	2 139	43	358	2 171
	Subtotal	3.07	26 160	531	4 382	26 558
	TOTAL FOR BASIN	3.07	26 160	531	4 382	26 558
BASIN: California						
Mexico						
Ciudad Obregon	Yaqui	0.21	1 754	36	294	1 781
Culiacan	Culiacan	0.37	3 130	64	524	3 178
Durango	Mezquital	0.26	2 208	45	370	2 241
Ensenada	Pacific Ocean	0.16	1 345	27	225	1 365
Hermosillo	Sonora	0.36	3 082	63	516	3 129
Mazatlan	Pacific Ocean	0.21	1 798	37	301	1 826
Mexicali	Colorado	0.40	3 364	68	564	3 416
Tijuana	Tijuana	0.64	5 467	111	916	5 550
	Subtotal	2.60	22 148	450	3 710	22 486
	TOTAL FOR BASIN	2.60	22 148	450	3 710	22 486

Annex 5 (cont.1)

Cities by major hydrographic basins, countries, and recipient water bodies		DOMESTIC SEWAGE OUTFLOWS (m3/sec)	DBO (Ton/year)	PHOSPHORUS (Ton/year)	NITROGEN (Ton/year)	SUSPENDED SOLIDS (Ton/year)
BASIN: Caribbean						
Colombia						
Armenia	Cauca	0.25	2 166	44	363	2 199
Barrancabermeja	Magdalena	0.19	1 651	34	277	1 676
Barranquilla	Magdalena	1.27	10 775	219	1 805	10 939
Bogota	Bogota	5.61	47 765	970	8 001	48 493
Bucaramanga	Lebrija	0.48	4 104	83	687	4 166
Cali	Cauca	1.87	15 910	323	2 665	16 152
Cartagena	Caribbean Sea	0.69	5 905	120	989	5 995
Ibague	Combeina	0.38	3 239	66	542	3 288
Manizales	Chinchina	0.39	3 305	67	554	3 356
Medellin	Medellin	2.00	17 047	346	2 856	17 306
Monteria	Sinu	0.22	1 892	38	317	1 921
Neiva	Magdalena	0.25	2 141	43	359	2 173
Palmira	Cauca	0.25	2 105	43	353	2 137
Pereira	Otun	0.33	2 803	57	470	2 846
Santa Marta	Caribbean Sea	0.25	2 138	43	358	2 171
Valledupar	Guatapuri	0.20	1 716	35	287	1 742
	Subtotal	14.65	124 662	2 531	20 882	126 560
Guatemala						
Guatemala City	Las Vacas	0.69	5 900	120	988	5 990
	Subtotal	0.69	5 900	120	988	5 990
Honduras						
San Pedro Sula	Chamelecon	0.26	2 194	45	368	2 227
Tegucigalpa	Grande	0.42	3 607	73	604	3 662
	Subtotal	0.68	5 801	118	972	5 889
Nicaragua						
Managua	Lake Managua	0.69	5 881	119	985	5 971
	Subtotal	0.69	5 881	119	985	5 971
	TOTAL FOR BASIN	16.71	142 244	2 888	23 828	144 410
BASIN: Caribbean Islands						
Cuba						
Bayamo	Bayamo	0.09	726	15	122	737
Camaguey	San Pedro	0.21	1 770	36	297	1 797
Cienfuegos	Cienfuegos Bay	0.09	741	15	124	752
Guantanamo	Caribbean Sea	0.14	1 206	24	202	1 224
Holguin	Holguin	0.16	1 348	27	226	1 368
La Habana	Almendares	1.63	13 912	282	2 330	14 123
Matanzas	Yumuri/San Juan	0.09	727	15	122	738
Santa Clara	Sagua La Grande	0.15	1 250	25	209	1 269
Santiago de Cuba	Caribbean Sea	0.30	2 533	51	424	2 571
	Subtotal	2.85	24 212	492	4 056	24 581
Dominican Republic						
Santo Domingo	Ozama	0.68	5 765	117	966	5 852
Stgo.de Los Caballeros	Yaque del Norte	0.15	1 248	25	209	1 267
	Subtotal	0.82	7 012	142	1 175	7 119
Haiti						
Port-Au-Prince (1982)	Bois de Chene	0.68	5 792	118	970	5 880
	Subtotal	0.68	5 792	118	970	5 880

Annex 5 (cont.2)

Cities by major hydrographic basins, countries, and recipient water bodies		DOMESTIC SEWAGE OUTFLOWS (m3/sec)	DBO (Ton/year)	PHOSPHORUS (Ton/year)	NITROGEN (Ton/year)	SUSPENDED SOLIDS (Ton/year)
BASIN: Caribbean Islands (cont.)						
<u>Jamaica</u>						
Kingston	Caribbean Sea	0.18	1 537	31	257	1 560
	Subtotal	0.18	1 537	31	257	1 560
<u>Puerto Rico</u>						
Bayamon	Cidra	n/a	n/a	n/a	n/a	n/a
Caguas	Loiza	n/a	n/a	n/a	n/a	n/a
Ponce	Caribbean Sea	n/a	n/a	n/a	n/a	n/a
San Juan	San José Lagoon	n/a	n/a	n/a	n/a	n/a
	Subtotal	n/a	n/a	n/a	n/a	n/a
	TOTAL FOR BASIN	4.53	38 553	783	6 458	39 140
BASIN: Central Venezuela						
<u>Venezuela</u>						
Barcelona/Pto.La Cruz	Caribbean Sea	0.45	3 799	77	636	3 857
Barquisimeto	Yaracuy	0.77	6 550	133	1 097	6 649
Caracas	Guaires	3.67	31 205	634	5 227	31 680
Cumana	Gulf of Cariaco	0.26	2 203	45	369	2 236
Departamento Vargas	Tuy	0.35	3 000	61	503	3 046
Maracay	Aragua	0.54	4 582	93	768	4 652
Valencia	Cabriales	0.87	7 377	150	1 236	7 489
	Subtotal	6.90	58 716	1 192	9 836	59 610
	TOTAL FOR BASIN	6.90	58 716	1 192	9 836	59 610
BASIN: Central system of Chile						
<u>Chile</u>						
Chillan	Itata	0.19	1 606	33	269	1 631
Concepcion	Biobio	0.43	3 641	74	610	3 697
Rancagua	Cachapoal	0.22	1 902	39	319	1 931
Santiago	Mapocho	5.84	49 679	1 009	8 322	50 436
Talca	Claro	0.21	1 747	35	293	1 774
Talcahuano	Pacific Ocean	0.32	2 751	56	461	2 793
Valparaiso-Viña del Mar	Pacific Ocean	0.85	7 267	148	1 217	7 378
	Subtotal	8.06	68 594	1 393	11 490	69 638
	TOTAL FOR BASIN	8.06	68 594	1 393	11 490	69 638
BASIN: Gulf of Mexico						
<u>Mexico</u>						
Jalapa de Enriquez	Actopan	0.23	1 945	39	326	1 974
Mexico City	Lake Texcoco/Tula	16.73	142 384	2 891	23 851	144 552
Poza Rica de Hidalgo	Purificacion	0.22	1 911	39	320	1 940
Tampico	Panuco	0.44	3 764	76	631	3 821
Veracruz	Jamapa	0.35	2 962	60	496	3 007
	Subtotal	17.97	152 966	3 106	25 624	155 295
	TOTAL FOR BASIN	17.97	152 966	3 106	25 624	155 295

Annex 5 (cont.3)

Cities by major hydrographic basins, countries, and recipient water bodies		DOMESTIC SEWAGE OUTFLOWS (m3/sec)	DBO (Ton/year)	PHOSPHORUS (Ton/year)	NITROGEN (Ton/year)	SUSPENDED SOLIDS (Ton/year)
BASIN: Interior of Argentina						
Argentina						
Cordoba	Primero	0.73	6 191	126	1 037	6 285
Rio Cuarto	Cuarto	0.08	694	14	116	705
San Miguel de Tucuman	Sali	0.37	3 133	64	525	3 180
San Salvador de Jujuy	San Francisco	0.09	785	16	131	797
Santiago del Estero	Dulce	0.11	935	19	157	949
	Subtotal	1.38	11 738	238	1 966	11 916
	TOTAL FOR BASIN	1.38	11 738	238	1 966	11 916
BASIN: Maracaibo						
Colombia						
Cucuta	Zulia	0.50	4 290	87	719	4 356
	Subtotal	0.50	4 290	87	719	4 356
Venezuela						
Cabimas	Lake Maracaibo	0.24	2 045	42	343	2 076
Maracaibo	Lake Maracaibo	1.21	10 331	210	1 731	10 488
	Subtotal	1.45	12 376	251	2 073	12 564
	TOTAL FOR BASIN	1.96	16 666	338	2 792	16 920
BASIN: North Pacific						
Mexico						
Acapulco	Pacific Ocean	0.52	4 461	91	747	4 529
Aguascalientes	Verde Grande	0.29	2 483	50	416	2 520
Cuernavaca	Apatacto	0.27	2 330	47	390	2 365
Guadalajara	Santiago	2.80	23 820	484	3 990	24 183
Irapuato	Turbio	0.18	1 555	32	260	1 578
Leon	Turbio	0.71	6 031	122	1 010	6 123
Morelia	Grande	0.28	2 423	49	406	2 460
Oaxaca	Atoyac or Verde	0.15	1 309	27	219	1 329
Puebla de Zaragoza	Atoyac	0.81	6 862	139	1 149	6 966
Queretaro	Huimilpan	0.21	1 794	36	300	1 821
Salamanca	Lerma	0.12	1 019	21	171	1 034
Tepic	Mololoa	0.16	1 350	27	226	1 371
Toluca de Lerdo	Lerma	0.27	2 335	47	391	2 371
Uruapan	Cupatitzio	0.17	1 419	29	238	1 441
Zapopan	Santiago	0.12	1 009	20	169	1 024
	Subtotal	7.07	60 199	1 222	10 084	61 116
	TOTAL FOR BASIN	7.07	60 199	1 222	10 084	61 116
BASIN: Orinoco						
Venezuela						
San Cristóbal	Carapo	0.37	3 120	63	523	3 168
	Subtotal	0.37	3 120	63	523	3 168
	TOTAL FOR BASIN	0.37	3 120	63	523	3 168
BASIN: Pacific: dry climate						
Chile						
Antofagasta	Pacific Ocean	0.30	2 521	51	422	2 560
Arica	Pacific Ocean	0.22	1 894	38	317	1 923
Iquique	Pacific Ocean	0.18	1 497	30	251	1 520
	Subtotal	0.69	5 912	120	990	6 002

Annex 5 (cont.4)

Cities by major hydrographic basins, countries, and recipient water bodies		DOMESTIC SEWAGE OUTFLOWS (m3/sec)	DBO (Ton/year)	PHOSPHORUS (Ton/year)	NITROGEN (Ton/year)	SUSPENDED SOLIDS (Ton/year)
BASIN: Pacific: dry climate (cont.)						
Peru						
Arequipa	Chili	0.57	4 843	98	811	4 916
Chiclayo	Lambayeque	0.36	3 029	61	507	3 075
Chimbote	Pacific Ocean	0.28	2 347	48	393	2 382
Ica	Pacific Ocean	0.15	1 244	25	208	1 263
Lima-Callao	Rimac	5.63	47 882	972	8 021	48 611
Piura	Piura	0.26	2 253	46	377	2 287
Trujillo	Pacific Ocean	0.45	3 839	78	643	3 897
	Subtotal	7.69	65 435	1 329	10 961	66 432
	TOTAL FOR BASIN	8.38	71 348	1 449	11 952	72 434
BASIN: Pacific: tropical climate						
Colombia						
Buenaventura	Pacific Ocean	0.23	1 927	39	323	1 956
Pasto	Guevara	0.28	2 372	48	397	2 408
	Subtotal	0.51	4 299	87	720	4 365
Costa Rica						
San Jose	Torres	0.26	2 195	45	368	2 228
	Subtotal	0.26	2 195	45	368	2 228
Ecuador						
Guayaquil	Guayas	1.00	8 543	173	1 431	8 673
Quito	Guayllabamba	0.74	6 314	128	1 058	6 411
	Subtotal	1.75	14 857	302	2 489	15 083
El Salvador						
San Salvador	Acelhuate	1.02	8 652	176	1 449	8 784
Santa Ana	n/a	0.46	3 943	80	661	4 003
	Subtotal	1.48	12 595	256	2 110	12 787
Panama						
Panama City	Pacific Ocean	0.65	5 521	112	925	5 605
	Subtotal	0.65	5 521	112	925	5 605
	TOTAL FOR BASIN	4.64	39 467	801	6 611	40 068
BASIN: Pampa						
Argentina						
Bahia Blanca	Atlantic Ocean	0.16	1 392	28	233	1 413
Mendoza	Mendoza	0.44	3 762	76	630	3 819
San Juan	San Juan	0.22	1 831	37	307	1 859
	Subtotal	0.82	6 985	142	1 170	7 091
	TOTAL FOR BASIN	0.82	6 985	142	1 170	7 091
BASIN: Plata						
Argentina						
Corrientes	Parana	0.13	1 132	23	190	1 149
Gran Buenos Aires	La Plata	7.35	62 582	1 271	10 483	63 535
Gran La Plata	La Plata	0.42	3 532	72	592	3 586
Mar del Plata	Atlantic Ocean	0.30	2 566	52	430	2 605
Parana	Parana	0.12	1 006	20	169	1 021
Posadas	Parana	0.10	882	18	148	896
Resistencia	Parana	0.16	1 377	28	231	1 398
Rosario	Parana	0.71	6 018	122	1 008	6 109
Salta	San Francisco	0.19	1 641	33	275	1 666
Santa Fe	Salado	0.21	1 811	37	303	1 838
	Subtotal	9.70	82 548	1 676	13 828	83 805

Annex 5 (cont.5)

Cities by major hydrographic basins, countries, and recipient water bodies		DOMESTIC SEWAGE OUTFLOWS (m3/sec)	DBO (Ton/year)	PHOSPHORUS (Ton/year)	NITROGEN (Ton/year)	SUSPENDED SOLIDS (Ton/year)
BASIN: Plata (cont.)						
Brazil						
Americana	Piracicaba	0.09	768	16	129	779
Anapolis	Meia Ponte	0.12	1 012	21	170	1 027
Aracatuba	Tiete	0.08	715	15	120	726
Araraquara	Jacare Guacu	0.10	826	17	138	838
Bauru	Bauru	0.13	1 128	23	189	1 145
Brasilia	Paranua Sta Maria	0.30	2 593	53	434	2 632
Campinas	Capivari	0.42	3 571	73	598	3 626
Carapicuiba	Tiete	0.14	1 171	24	196	1 189
Cuiaba	Cuiaba	0.12	1 058	21	177	1 075
Curitiba	Belem	0.62	5 319	108	891	5 400
Diadema	Tiete	0.17	1 441	29	241	1 463
Franca	Grande	0.11	905	18	152	919
Goiania	Meia Ponte	0.52	4 433	90	743	4 501
Guarulhos	Cabuu Cima	0.29	2 491	51	417	2 529
Jundiai	Guapeva	0.16	1 324	27	222	1 344
Lajes	Caveiras	0.08	686	14	115	696
Limeira	Piracicaba	0.10	869	18	146	882
Londrina	Tibaji	0.19	1 627	33	273	1 652
Marilia	Do Peixe	0.08	703	14	118	714
Maringa	Ivai	0.12	996	20	167	1 012
Maua	Tiete	0.15	1 297	26	217	1 317
Mogi das Cruzes	Paraitinga	0.09	771	16	129	782
Osasco	Tiete	0.35	2 987	61	500	3 033
Piracicaba	Piracicaba	0.13	1 131	23	189	1 148
Ponta Grossa	Tibaji	0.13	1 079	22	181	1 095
Presidente Prudente	Santo Anastacio	0.09	805	16	135	817
Ribeirao Preto	Pardo	0.22	1 896	38	318	1 925
Santo Andre	Tiete	0.41	3 463	70	580	3 515
Sao Caetano do Sul	Tiete	0.12	1 028	21	172	1 043
Sao Carlos	Jacare Guacu	0.08	689	14	115	699
Sao Jose do Rio Preto	Preto	0.13	1 084	22	182	1 101
Sao Paulo	Tiete	5.21	44 339	900	7 427	45 015
Sorocaba	Sorocaba	0.19	1 606	33	269	1 630
Uberaba	Grande	0.13	1 137	23	190	1 154
Uberlandia	Uberarinha	0.17	1 452	29	243	1 475
	Subtotal	11.56	98 399	1 998	16 483	99 897
Paraguay						
Asuncion	Paraguay	0.32	2 692	55	451	2 733
	Subtotal	0.32	2 692	55	451	2 733
Uruguay						
Montevideo	Atlantic Ocean	0.43	3 688	75	618	3 744
	Subtotal	0.43	3 688	75	618	3 744
	TOTAL FOR BASIN	22.01	187 326	3 804	31 379	190 179
BASIN: Rio Bravo						
Mexico						
Chihuahua	Chuviscar	0.44	3 726	76	624	3 782
Ciudad Juarez	Bravo	0.71	6 034	123	1 011	6 125
Matamoros	Bravo	0.22	1 866	38	313	1 894
Monterrey	Pesqueria	2.29	19 486	396	3 264	19 783
Nuevo Laredo	Bravo	0.25	2 158	44	362	2 191
Reynosa	Bravo	0.26	2 231	45	374	2 265
Saltillo	Pesqueria	0.29	2 495	51	418	2 533
	Subtotal	4.46	37 995	771	6 365	38 574
	TOTAL FOR BASIN	4.46	37 995	771	6 365	38 574

Cities by major hydrographic basins, countries, and recipient water bodies		DOMESTIC SEWAGE OUTFLOWS (m3/sec)	DBO (Ton/year)	PHOSPHORUS (Ton/year)	NITROGEN (Ton/year)	SUSPENDED SOLIDS (Ton/year)
BASIN: San Francisco						
Brazil						
Belo Horizonte	Das Velhas	1.07	9 093	185	1 523	9 232
Divinopolis	Para	0.08	683	14	114	693
Montes Claros	Verde	0.11	957	19	160	972
	Subtotal	1.26	10 734	218	1 798	10 897
	TOTAL FOR BASIN	1.26	10 734	218	1 798	10 897
BASIN: South Atlantic						
Brazil						
Aracaju	Atlantic Ocean	0.21	1 816	37	304	1 844
Barra Mansa	Paraiba do Sul	0.09	778	16	130	790
Blumenau	Itajai	0.11	913	19	153	927
Campos	Paraiba do Sul	0.13	1 098	22	184	1 115
Canoas	Dos Sinos	0.16	1 350	27	226	1 370
Caxias do Sul	Piauhi	0.15	1 253	25	210	1 272
Duque de Caxias	Niteroi	0.23	1 929	39	323	1 959
Feira de Santana	Jacuipe	0.17	1 418	29	238	1 440
Florianopolis	Atlantic Ocean	0.11	968	20	162	983
Governador Valadares	Doce	0.13	1 095	22	183	1 112
Itabuna	Colonia	0.10	819	17	137	832
Joinvile	Sao Francisco Bay	0.16	1 368	28	229	1 389
Juiz de Fora	Paraibuna	0.22	1 889	38	317	1 918
Nilopolis	Atlantic Ocean	0.12	1 060	22	178	1 076
Niteroi	Atlantic Ocean	0.29	2 435	49	408	2 472
Nova Iguacu	Atlantic Ocean	0.36	3 100	63	519	3 148
Novo Hamburgo	Dos Sinos	0.10	833	17	139	845
Pelotas	Lagoa dos Patos	0.15	1 242	25	208	1 261
Petropolis	Piabanha	0.11	942	19	158	956
Porto Alegre	Guaiba	0.82	6 990	142	1 171	7 097
Rio Grande	Lagoa dos Patos	0.09	786	16	132	798
Rio de Janeiro	Guanabara Bay	3.77	32 108	652	5 378	32 597
Salvador	Atlantic Ocean	1.11	9 433	192	1 580	9 576
Santa Maria	Bagu	0.11	953	19	160	968
Santos	Atlantic Ocean	0.30	2 591	53	434	2 631
Sao Bernardo do Campo	Cubatao	0.28	2 403	49	403	2 440
Sao Goncalo	Atlantic Ocean	0.16	1 395	28	234	1 416
Sao Joao de Meriti	Atlantic Ocean	0.16	1 327	27	222	1 348
Sao Jose dos Campos	Paraiba do Sul	0.20	1 690	34	283	1 716
Sao Vicente	Atlantic Ocean	0.14	1 215	25	204	1 234
Taubate	Paraiba do Sul	0.12	979	20	164	994
Vitoria	Atlantic Ocean	0.11	909	18	152	923
Vitoria da Conquista	Pardo	0.09	793	16	133	805
Volta Redonda	Paraiba do Sul	0.13	1 121	23	188	1 138
	Subtotal	10.69	91 002	1 848	15 244	92 388
	TOTAL FOR BASIN	10.69	91 002	1 848	15 244	92 388
BASIN: South Pacific						
Chile						
Temuco	Imperial	0.25	2 143	44	359	2 175
	Subtotal	0.25	2 143	44	359	2 175
	TOTAL FOR BASIN	0.25	2 143	44	359	2 175

Annex 5 (concl.)

Cities by major hydrographic basins, countries, and recipient water bodies		DOMESTIC SEWAGE OUTFLOWS (m3/sec)	DBO (Ton/year)	PHOSPHORUS (Ton/year)	NITROGEN (Ton/year)	SUSPENDED SOLIDS (Ton/year)
BASIN: Southern Interior						
Mexico						
Gomez Palacio	Nazas	0.12	994	20	167	1 009
San Luis Potosi	n/a	0.37	3 160	64	529	3 208
Torreon	Nazas	0.46	3 931	80	659	3 991
	Subtotal	0.95	8 085	164	1 354	8 209
	TOTAL FOR BASIN	0.95	8 085	164	1 354	8 209
BASIN: Titicaca						
Bolivia						
Oruro	Tagarete	0.08	690	14	116	700
	Subtotal	0.08	690	14	116	700
	TOTAL FOR BASIN	0.08	690	14	116	700
BASIN: Yucatan						
Mexico						
Merida	Gulf of Mexico	0.31	2 602	53	436	2 642
	Subtotal	0.31	2 602	53	436	2 642
	TOTAL FOR BASIN	0.31	2 602	53	436	2 642
GRAND TOTAL		127.14	1 082 028	21 970	181 253	1 098 505

n/a = Information has not been available.

Note: Small differences in totals/subtotals are due to rounding.

Annex 6

INSTALLED CAPACITY OF SELECTED INDUSTRIES, BY WATER BODY

A. PULP AND PAPER INDUSTRY
(installed capacity, tons)

Location of the plant	Cellulose	Paper	Water body
Basin: Amazon			
<u>Bolivia</u>			
La Paz	700	1 500	Choqueyapu
Total for basin	700	1 500	
Basin: Arid Pacific			
<u>Peru</u>			
Chacoilayo	0	8 300	Rimac
Chiclayo Cayalti	3 000	4 000	Reque
Chosica	0	14 000	Rimac
Lima	0	5 000	Pacific Ocean
Lima Viejo	0	3 000	Rimac
Paramonga	60 000	85 000	Fortaleza
Trujillo	49 500	66 000	Pacific Ocean
Ventanilla	0	5 000	Rimac
Vitarte	0	500	Pacific Ocean
Total for basin	112 500	190 800	
Basin: Brazil, North-East			
<u>Brazil</u>			
Beberibe	7 500	5 100	Choro
Campina Grande	1 840	4 420	Paraiba
Fortaleza	0	310	Atlantic Ocean
Jaboatao	11 600	20 400	Jaboatao
Moreno	1 700	4 100	Jaboatao
Total for basin	22 640	34 330	
Basin: Caribbean			
<u>Colombia</u>			
Barranquilla	0	1 90o	Magdalena
Bogota	4 000	13 200	Bogota
Cali	137 200	203 600	Cauca
Medellin	0	3 000	Medellin
Pereira	0	5 100	Otun
Total for basin	141 200	226 800	
Basin: Central Chile			
<u>Chile</u>			
Biobio	66 000	64 600	Biobio
Laja	240 000	17 000	Laja
Laja Grown	0	49 000	Laja
Nacimiento	75 000	70 000	Biobio
Puente Alto	15 000	58 000	Maipo
Santiago	0	10 000	Mapocho
Talca	0	3 000	Claro
Vina del Mar	2 000	4 500	Pacific Ocean
Total for basin	398 000	276 100	

Annex 6 (cont.1)

Location of the plant	Cellulose	Paper	Water body
Basin: Central Venezuela			
<u>Venezuela</u>			
Caracas	0	2 000	Guaires
Guacara	0	23 000	Lake Valencia
Maracay	0	63 000	Aragua
Moron	25 000	95 000	Moron
Petare	0	27 000	Guaires
Valencia	0	63 000	Quebrada Seca
Total for basin	25 000	273 000	
Basin: Gulf of Mexico			
<u>Mexico</u>			
Apizaco	3 600	0	Zavapan
Ayotla	58 500	18 000	Lake Texcoco/Tula
Azcapotzalco	0	19 500	Lake Texcoco/Tula
Cam. Mexico City--Laredo	60 000	77 000	San Javier
Cam. Mexico City-Texcoco	0	24 000	Lake Texcoco/Tula
Colonia Goaja	0	25 000	Lake Texcoco/Tula
Colonia Maco	0	15 000	Lake Texcoco/Tula
Colonia Panamericana	0	1 500	Lake Texcoco/Tula
Ixtapalapa	0	15 000	Lake Texcoco/Tula
Ixtapaluca	0	2 500	Lake Texcoco/Tula
La Paz	0	3 000	Lake Texcoco/Tula
Los Reyes	23 400	79 000	Lake Texcoco/Tula
Mexico City	4 100	128 000	Lake Texcoco/Tula
Orizaba	4 740	0	Blanco
San Pedro Xalostoc	5 100	0	
San Rafael	130 000	118 500	Lake Texcoco/Tula
Santa Clara	6 000	6 500	
Tlalnepantla	0	56 500	Tlalnepantla
Tlalpan	31 700	55 000	Lake Texcoco/Tula
Tuxtepec	58 100	50 000	Santo Domingo
Uaucalran de Juarez	0	20 500	
Total for basin	385 240	714 500	
Basin: Interior of Argentina			
<u>Argentina</u>			
Bellavista	1 500	2 000	Sali
Cordoba	0	9 000	Primero
Leales	6 000	6 000	Sali
Lib.Gral.San Martin	30 000	36 000	San Francisco
Oncativo	0	1 500	
Rio Ju	0	2 000	Cuarto
Tucuman	2 000	3 500	Sali
Total for basin	39 500	60 000	
Basin: North Pacific			
<u>Mexico</u>			
Atenquique	40 000	70 000	Tuxpan
Atizapan	0	8 500	Lerma
Cuernavaca	0	20 000	Apataclo
Guadalajara	0	15 000	Santiago
Puebla	0	19 000	Atoyac
Salvatierra	1 500	0	Pesqueria
San Bartolo	2 000	35 000	Lerma
Texmelucan	0	10 000	Atoyac
Total for basin	43 500	177 500	

Annex 6 (cont.2)

Location of the plant	Cellulose	Paper	Water body
Basin: Northern Interior			
<u>Mexico</u>			
Anahuac	1 200	0	Santa Isabel
Total for basin	1 200	0	
Basin: Pampa			
<u>Argentina</u>			
Cipoletti	0	1 500	Neuquen
Godoy Cruz	0	30 000	Mendoza
Tornquist	0	6 000	Sauce Chico
Total for basin	0	37 500	
Basin: Plata			
<u>Argentina</u>			
Alma Fuerte	4 000	6 000	Tercero
Andino	0	8 500	Carcarana
Avellaneda	0	21 000	Riachuelo
Azul	2 000	3 000	Azul
Baradero	0	4 000	Baradero
Beccar	0	12 000	La Plata
Berazategui	0	6 000	La Plata
Bernal	20 000	102 000	La Plata
Buenos Aires	0	40 000	La Plata
Campana	4 000	22 500	Parana
Canada de Gomez	2 000	3 500	Canada De Gomez
Capitan Bermudez	40 000	70 000	Parana
Ciudadella	0	1 500	La Plata
Cordoba	0	4 000	Primero
Coronel Suarez	6 000	6 000	Vilimanla
General Lagos	0	3 000	Parana
General Pacheco	0	1 500	Reconquista
Hurlingham	6 000	10 000	Reconquista
Ituzaingo	0	2 500	Reconquista
Lanus	0	14 000	Riachuelo
Las Palmas	4 000	4 000	Paraguay
Lomas de Zamora	0	2 000	La Plata
Mercedes	0	1 500	Moyano
Parana	0	4 500	Parana
Puerto Piray	30 000	5 000	Parana
Quilmes	0	26 000	La Plata
Ranelagh	4 000	12 000	La Plata
Ringuelet	0	5 000	La Plata
Rosario	0	1 500	Parana
S Jose de la Esquina	6 000	6 000	Parana
Salto	0	1 000	Salto
San Fernando	0	3 000	La Plata
San Isidro	1 000	2 000	La Plata
San Justo	65 000	160 000	La Plata
San Lorenzo	3 000	7 500	Parana
San Martin	2 000	3 500	Atlantic Ocean
San Pedro	2 500	4 500	Parana
Tandil	0	2 000	Langueyo
Torcuato	0	3 000	Reconquista
Valentin Alsina	0	11 500	Riachuelo
Vellaneda	0	3 000	Riachuelo
Vicente Lopez	0	7 000	La Plata
Villa Dominico	0	15 000	La Plata
Villa G. Galvez	0	2 000	La Plata
Villa Ocampo	6 000	14 000	Parana
Wilde	0	32 000	La Plata
Zarate	64 000	76 000	Parana de Las Palmas
Subtotal	271 500	755 500	

Annex 6 (cont.3)

Location of the plant	Cellulose	Paper	Water body
Basin: Plata (cont.)			
Brazil			
Americana	0	6 800	Atibaia
Arapoti	2 040	6 120	Barra Mansa
Araras	0	2 040	Araras
Cacador	6 800	5 100	Do Peixe
Caiciras	11 900	27 000	Juqueri
Campinas	2 380	5 440	Capavari
Canuinhas	0	1 360	Canuinhas
Capital	3 400	20 400	Tiete
Cordeiro Polis	0	10 540	Tatu
Curitiba	7 480	11 560	Belem
Embu	340	10 690	Embu Murun
Guara	0	3 400	Pontal
Guarul Hnos.	0	2 400	*Cabussu de Cana*
Guarulhos	13 600	10 200	Tiete
Guaynazas	0	3 400	Tiete
Irapuru	0	2 040	Da Inha
Itapira	680	3 400	Da Renha
Itaquera	0	2 380	Tiete
Itiutaba	0	4 080	Tejuco
Joacaba	5 400	10 900	Do Peixe
Jundiai	2 040	4 760	Jundiai
Limeira	2 720	21 250	Tatu
Marilia	0	3 400	Cinc
Mato Grosso	0	5 100	Mato Grosso
Mogi Guacu	68 000	17 000	Mogi Guacu
Mogi das Cruzes	0	4 100	Tiete
Monte Alegre	125 800	203 320	Tibaji
Nova	0	2 040	Independencia
Ojasco	0	2 700	Tiete
Palmas	0	2 040	Do Peixe
Paracicaba	6 800	14 960	Paracicaba
Penapolis	0	1 700	Laje
Pirassununga	850	3 740	Mogi Guacu
Pirituba Suzano	0	11 900	Tiete
Ponta Grossa	0	3 400	Refugio de Piedra
Ribeirao Pires	0	6 800	Grande
Ribeirao Preto	0	3 060	Pardo
Rio Claro	0	2 040	Claro
Salto	0	12 900	Tiete
Santa Barbara	0	2 040	Dos Toledos
Santana de Parnaiba	40 800	0	Tiete
Santo Amaro	0	2 700	Pinheiros
Sao Bernardo	0	2 380	Do Meninos
Sao Carlos	0	5 440	Jacare Guacu
Sao Paulo	9 690	76 500	Tiete
Suzano	61 200	40 100	Tiete
Valinhos	14 280	8 800	Atibaia
Subtotal	386 200	613 420	
Paraguay			
Asuncion	0	1 200	Paraguay
Subtotal	0	1 200	
Uruguay			
Juan L Lacazo	8 000	18 700	La Plata
Mercedes	4 800	9 800	Negro
Montevideo	800	27 100	Atlantic Ocean
Subtotal	13 600	55 600	
Total for basin	671 300	1 425 720	

Annex 6 (cont.4)

Location of the plant	Cellulose	Paper	Water body
Basin: Rio Bravo			
Mexico			
Chihuahua	0	16 000	Chuviscar
Monterrey	20 400	61 900	Pesqueria
Rio Bravo	6 000	0	Bravo
San Nicolas	3 500	35 000	Pantano
San Nicolas de Garza	27 000	40 000	Pantano
Total for basin	56 900	152 900	
Basin: South Atlantic			
Brazil			
Adolfo Pinheiro	0	240	Paraiba do Sul
Alcantara	8 500	11 600	Da Aldeia
Alem Paraiba	0	10 370	Paraiba do Sul
Aparecida del Norte	20 400	0	Paraiba do Sul
Aracaju	170	3 400	Atlantic Ocean
Cambara	20 400	0	Das Antas
Campos	0	3 200	Paraiba do Sul
Canela	11 200	5 400	Cahi
Canoas	20 400	19 700	Dos Sinos
Cantagalo	0	2 700	Negro
Cataguases	5 100	11 220	Pomba
Cubatao	0	19 000	Cubatao
Esteio	0	4 400	Dos Sinos
Guaiba	17 000	20 100	Guaiba
Itaba Poana	0	2 700	Itaba Poana
Itajai	2 700	7 100	Atlantic Ocean
Jacare	40 800	59 160	Jaguari
Jacarepagua	0	5 100	Jacarepagua Lagoon
Juiz de Fora	0	11 220	Paraibuna
Mendes	0	9 500	Sacra Familia
Natal	680	1 700	Mucuri
Paraibuna	0	1 700	Paraibuna
Pelotas	3 400	6 600	Lagoa Dos Patos
Petropolis	0	12 200	Piabanha
Pindamonhangaba	10 200	12 220	Paraiba do Sul
Ponte Nova	680	6 120	Pitunga
Prates	0	3 400	Jequitinhonda
Rio Grandina Nova	2 700	3 400	Bengala
Rio de Janeiro	0	22 270	Guanabara Bay
Salvador	850	3 230	Atlantic Ocean
San Antonio de Padua	0	3 600	Pomba
San Leopoldo	0	6 100	Dos Sinos
Sao Geraldo	1 870	4 420	Sao Geraldo
Total for basin	167 050	293 070	
Basin: South Pacific			
Chile			
Valdivia	5 800	10 200	Calle Calle
Total for basin	5 800	10 200	

Annex 6 (cont.5)

Location of the plant	Cellulose	Paper	Water body
Basin: Tropical Pacific			
Ecuador			
Quito	0	700	Guayllabamba
San Carlos	0	9 000	Guayas
Subtotal	0	9 700	
El Salvador			
San Salvador	0	12 800	Acelhuate
Subtotal	0	12 800	
Guatemala			
Escuintla	0	24 000	Michatoya
Guatemala	0	5 300	Las Vacas
Subtotal	0	29 300	
Panama			
Panama	0	28 000	Pacific Ocean
Subtotal	0	28 000	
Total for basin	0	79 800	
GRAND TOTAL	2 070 530	3 953 720	

Source: Various national sources.

B. PETROLEUM REFINERIES
(installed capacity)

Location of the plant	Barrels a/	Water body
Basin: Amazon		
Bolivia		
Camir	1 000	Parapeti
Cochabamba	25 000	Rocha
Santa Cruz	24 000	Pirai
Subtotal	50 000	
Brazil		
Manaos	9 700	Amazon
Subtotal	9 700	
Colombia		
Mocoa	1 000	Mocoa
Subtotal	1 000	
Ecuador		
Lago Agrio	1 000	Napo
Subtotal	1 000	
Peru		
Iquitos	1 200	Amazon
Pucallpa	2 500	Ucayali
Subtotal	3 700	
Total for basin	65 400	
Basin: Arid Pacific		
Peru		
Conchan	850	Pacific Ocean
La Pampilla	100 000	Pacific Ocean
Marsella	1 400	Pacific Ocean
Talara	65 000	Magdalena
Total for basin	167 250	
Basin: Brazil, North-East		
Brazil		
Fortaleza	4 200	Atlantic Ocean
Total for basin	4 200	
Basin: Caribbean		
Colombia		
Barrancabermeja	110 000	Magdalena
Cartagena	5 000	Caribbean Sea
El Guamo	2 500	Luisa
La Dorada	5 000	Magdalena
Subtotal	122 500	
Costa Rica		
Puerto Limon	12 000	Caribbean Sea
Subtotal	12 000	
Guatemala		
Puerto Barrios	11 000	Caribbean Sea
Subtotal	11 000	
Honduras		
Puerto Cortes	14 000	Caribbean Sea
Subtotal	14 000	
Nicaragua		
Managua	16 000	Lake Managua
Subtotal	16 000	

Annex 6 (cont.7)

Location of the plant	Barrels a/	Water body
Basin: Caribbean (cont.)		
Panama		
Las Minas Colon	100 000	Lake Gatun
Subtotal	100 000	
Total for basin	275 500	
Basin: Central Chile		
Chile		
Con Con	69 000	Pacific Ocean
Concepcion	75 000	Pacific Ocean
Total for basin	144 000	
Basin: Central Venezuela		
Venezuela		
Amuay	653 000	Gulf of Venezuela
Cardon	305 000	Gulf of Venezuela
Dpto. La Cruz	195 000	Caribbean Sea
El Chaure	195 000	Caribbean Sea
El Palito	105 000	Caribbean Sea
San Roque	5 300	Guere
Total for basin	1 458 300	
Basin: Gulf of Mexico		
Mexico		
Azcapotzalco	105 000	Lake Texcoco/Tula
Ciudad Madero	175 000	Gulf of Mexico
Minatitlan	270 000	Coatzacoalcos
Poza Rica	27 000	Cazones
Tula	150 000	Tula
Total for basin	727 000	
Basin: Maracaibo		
Colombia		
Tibu	5 000	Tibu
Subtotal	5 000	
Venezuela		
Maracaibo	61 000	Lake of Maracaibo
Subtotal	61 000	
Total for basin	66 000	
Basin: North Pacific		
Mexico		
Salamanca	210 000	Lerma
Salina Cruz	170 000	Pacific Ocean
Total for basin	380 000	
Basin: Orinoco		
Venezuela		
Obispos	5 000	Santo Domingo
Total for basin	5 000	

Annex 6 (cont.8)

Location of the plant	Barrels a/	Water body
Basin: Pampa		
Argentina		
Bahia Blanca	13 850	Atlantic Ocean
Dpto. Galvan	17 000	Atlantic Ocean
Lujan de Cuyo	105 384	Mendoza
Plaza Huincul	23 485	Neuquen
Total for basin	159 719	
Basin: Patagonia		
Argentina		
Comodoro Rivadavia	6 300	Atlantic Ocean
San Sebastian	10	Atlantic Ocean
Total for basin	6 310	
Basin: Plata		
Argentina		
Buenos Aires	118 011	La Plata
Campana	92 000	Parana
Campo Duran	27 099	Bermejo
La Plata	216 789	La Plata
Lomas de Zamora	2 000	La Plata
Quilmes	60	La Plata
San Lorenzo	33 121	Parana
Subtotal	489 080	
Bolivia		
San Andita	50	Pilcomayo
Sucre	3 000	Caine
Subtotal	3 050	
Brazil		
Araucaira	120 600	Parana
Paulinia	325 000	Pilcomayo
Subtotal	445 600	
Paraguay		
Villa Elisa	5 000	Paraguay
Subtotal	5 000	
Uruguay		
La Teja	43 000	La Plata
Subtotal	43 000	
Total for basin	985 730	
Basin: Rio Bravo		
Mexico		
Cadereyta	100 000	San Juan
Reynosa	20 500	Bravo
Total for basin	120 500	
Basin: San Francisco		
Brazil		
Betim	72 400	Paraopeba
Total for basin	72 400	

Annex 6 (cont.9)

Location of the plant	Barrels a/	Water body
Basin: South Atlantic		
Brazil		
Canoas	72 400	Dos Sinos
Capuava	3 300	Atlantic Ocean
Cubatao	162 900	Cubatao
Duque de Caxias	256 200	Niteroi
Mataripe	132 700	Atlantic Ocean
Rio Grande	9 300	Lagoa dos Patos
Rio de Janeiro	950	Guanabara Bay
Santo Andre	33 800	Cubatao
Total for basin	671 550	
Basin: South Pacific		
Chile		
Magallanes	1 500	Strait of Magellan
Total for basin	1 500	
Basin: Tropical Pacific		
Ecuador		
Esmeraldas	36 000	Pacific Ocean
La Libertad	8 000	Pacific Ocean
Subtotal	44 000	
El Salvador		
Acajutla	17 000	Pacific Ocean
Subtotal	17 000	
Guatemala		
Escuintla	14 000	Michatoya
Subtotal	14 000	
Total for basin	75 000	
GRAND TOTAL	5 385 359	

Source: OLADE, 1979.

a/ Barrels per day of operation.

C. IRON AND STEEL INDUSTRY
(tons)

Location of the plant	Installed capacity	Water body
Basin: Arid Pacific		
Peru		
Chimbote	500 000	Pacific Ocean
Total for basin	500 000	
Basin: Brazil, North-East		
Brazil		
Recife	243 000	Atlantic Ocean
Total for basin	243 000	
Basin: Central Chile		
Chile		
Talcahuano	700 000	Biobio
Total for basin	700 000	
Basin: Central Venezuela		
Venezuela		
Barcelona	6 000	Caribbean Sea
Barquisimeto	79 200	Turbio
Caracas	175 000	Guaires
Total for basin	260 200	
Basin: Gulf of Mexico		
Mexico		
San Cosme Xalostoc	80 000	Zavapan
Veracruz	400 000	Jamapa
Total for basin	480 000	
Basin: Interior of Argentina		
Argentina		
Est.Gral. San Martin	210 000	San Francisco
Total for basin	210 000	
Basin: Maracaibo		
Venezuela		
Ciudad Ojeda	10 000	Lake Maracaibo
Maracaibo	12 000	Lake Maracaibo
Total for basin	22 000	
Basin: North Pacific		
Mexico		
Lazaro Cardenas	1 300 000	Pacific Ocean
San Miguel Xoxtla	450 000	Atoyac
Total for basin	1 750 000	
Basin: Orinoco		
Venezuela		
Bolivar	4 270 000	Orinoco
Total for basin	4 270 000	

Annex 6 (cont.11)

Location of the plant	Installed capacity	Water body
Basin: Pampa		
Argentina		
Bragado	135 000	Salado
Total for basin	135 000	
Basin: Plata		
Argentina		
Buenos Aires	2 750 000	La Plata
Campana	385 000	Parana
Tablada	260 000	La Plata
Villa Constitucion	224 000	Parana
Subtotal	3 619 000	
Brazil		
Lencois Paulista	40 000	Paranapanema
Mogi das Cruzes	511 000	Tiete
Piracicaba	290 000	Piracicaba
Sao Paulo	430 000	Tiete
Subtotal	1 271 000	
Total for basin	4 890 000	
Basin: Rio Bravo		
Mexico		
Monclova	3 300 000	Nadadores
Monterrey	1 000 000	Pesqueria
San Nicolas	555 000	Pesqueria
Total for basin	4 855 000	
Basin: San Francisco		
Brazil		
Belo Horizonte	902 000	Das Velhas
Contagem	80 000	Das Velhas
Divinopolis	209 000	Paraca
Total for basin	1 191 000	
Basin: South Atlantic		
Brazil		
Barra Mansa	210 000	Paraiba do Sul
Coronel Fabriciano	660 000	Doce
Cubatao	2 448 000	Cubatao
Ipatinga	2 763 000	Doce
Pindamonhangaba	270 000	Paraiba do Sul
Porto Alegre	336 000	Guaiba
Rio de Janeiro	786 000	Guanabara Bay
Salvador	254 000	Atlantic Ocean
San Jeronimo	179 000	Jacui
Santo Amaro	7 000	Paraiba do Sul
Sao Goncalo	56 000	Guanabara Bay
Vitoria	162 000	Atlantic Ocean
Volta Redonda	2 970 000	Paraiba do Sul
Total for basin	11 101 000	
Basin: unspecified		
Unspecified		
Unspecified	870 000	
Total for basin	870 000	
GRAND TOTAL	31 477 200	

Source: ILAFA, 1974.

D. NON-FERROUS METAL INDUSTRY
(tons)

Location of the plant	Installed capacity	Water body
TYPE OF INDUSTRY : Aluminium		
Basin: Guayanas		
<u>Suriname</u>		
Paranam	66 000	
Total for basin	66 000	
Basin: Gulf of Mexico		
<u>Mexico</u>		
Veracruz	45 000	Jamapa
Total for basin	45 000	
Basin: Orinoco		
<u>Venezuela</u>		
Ciudad Guayana	400 000	Orinoco
Total for basin	400 000	
Basin: Patagonia		
<u>Argentina</u>		
Puerto Madryn	140 000	Atlantic Ocean
Total for basin	140 000	
Basin: Plata		
<u>Brazil</u>		
Pocas de Caldas	90 000	Pardo
Sorocaba	120 200	Sorocaba
Total for basin	210 200	
Basin: South Atlantic		
<u>Brazil</u>		
Aratu	58 000	Jacuipe
Saramenha Ouro Preto	60 000	Doce
Total for basin	118 000	
Total for industry	979 200	
TYPE OF INDUSTRY : Copper (refining)		
Basin: Amazon		
<u>Peru</u>		
La Oroya	55 000	Negro
Total for basin	55 000	
Basin: Arid Pacific		
<u>Chile</u>		
Chuquicamata	370 000	Loa
Mantos Blancos	31 000	Loa
Paipote	72 000	Copiapo
Potrerillos	85 000	Salado
Subtotal	558 000	

Annex 6 (cont.13)

Location of the plant	Installed capacity	Water body
Type of industry: Copper (refining) Basin : Arid Pacific (cont.)		
Peru		
Cerro Verde	33 000	Pacific Ocean
Ilo	150 000	
Subtotal	183 000	
Total for basin	741 000	
Basin: Central Chile		
Chile		
Caletones	130 000	Cachapoal
Las Ventanas	222 600	Pacific Ocean
Santiago	16 000	Mapocho
Total for basin	368 600	
Basin: Gulf of Mexico		
Mexico		
Azcapotzalco	75 300	Lake Texcoco/Tula
Total for basin	75 300	
Total for industry	1 239 900	
TYPE OF INDUSTRY : Copper (smelting)		
Basin: Amazon		
Peru		
La Oroya	182 400	Negro
Total for basin	182 400	
Basin: Arid Pacific		
Chile		
Chuquicamata	940 000	Loa
Potrerillos	245 000	Salado
Subtotal	1 185 000	
Peru		
Ilo	456 000	Pacific Ocean
Subtotal	456 000	
Total for basin	1 641 000	
Basin: California		
Mexico		
Cananea	126 300	Bocomuchi
Santa Rosalia	45 600	Gulf of California
Total for basin	171 900	
Basin: Central Chile		
Chile		
Chagres	86 000	Aconcagua
Las Ventanas	255 000	Pacific Ocean
Total for basin	341 000	

Annex 6 (cont.14)

Location of the plant	Installed capacity	Water body
Type of industry: Cooper (smelting) (cont.)		
Basin: Southern Interior		
Mexico		
San Luis Potosi	136 800	
Total for basin	136 800	
Total for industry	2 473 100	
TYPE OF INDUSTRY : Lead (smelting and refining)		
Basin: Amazon		
Peru		
La Oroya	90 000	Negro
Total for basin	90 000	
Basin: Interior of Argentina		
Argentina		
Abra Pampa	1 500	
Total for basin	1 500	
Basin: Plata		
Argentina		
Puerto Vilelas	30 000	Parana
Subtotal	30 000	
Brazil		
Panelas	19 000	Urra
Subtotal	19 000	
Total for basin	49 000	
Basin: Rio Bravo		
Mexico		
Chihuahua	136 800	Chuviscar
Total for basin	136 800	
Basin: South Atlantic		
Brazil		
Santo Amaro	22 000	Paraiba
Total for basin	22 000	
Basin: Southern Interior		
Mexico		
Torreon	210 000	Nazas
Total for basin	210 000	
Total for industry	509 300	

Annex 6 (cont.15)

Location of the plant	Installed capacity	Water body
TYPE OF INDUSTRY : Zinc (electrolitical)		
Basin: Amazon		
<u>Peru</u>		
La Oroya	34 500	Negro
Total for basin	34 500	
Basin: Plata		
<u>Argentina</u>		
Borghi	13 000	Parana
Total for basin	13 000	
Basin: San Francisco		
<u>Brazil</u>		
Tres Marias	32 800	San Francisco
Total for basin	32 800	
Basin: South Atlantic		
<u>Brazil</u>		
	15 700	Paraibuna
Itaquai	5 900	Itaquai
Total for basin	21 600	
Basin: Southern Interior		
<u>Mexico</u>		
Torreon	47 880	Nazas
Total for basin	47 880	
Total for industry	149 780	
TYPE OF INDUSTRY : Zinc (smelting)		
Basin: Patagonia		
<u>Argentina</u>		
Comodoro Rivadavia	16 000	Atlantic Ocean
Total for basin	16 000	
Basin: Rio Bravo		
<u>Mexico</u>		
Rosita	61 000	Sabinas
Saltillo	30 000	Pesqueria
Total for basin	91 000	
Basin: Southern Interior		
<u>Mexico</u>		
San Luis Potosi	113 000	
Total for basin	113 000	
Total for industry	220 000	

<u>Source</u>: Non-Ferrous Metal Data, 1983, American Bureau of Metal Statistics

E. THERMAL ELECTRIC POWER GENERATING STATIONS

Location of the plant	Capacity (MW)	Water body
Basin: Amazon		
Brazil		
Belem	130	Marajo Bay
Manaos	69	Amazon
Total for basin	199	
Basin: Arid Pacific		
Chile		
Antofagasta	21	Pacific Ocean
Barquito	68	Pacific Ocean
Chuquicamata	23	
Pedro de Valdivia	24	
Tocopilla	200	Pacific Ocean
Total for basin	336	
Basin: California		
Mexico		
Ahome	41	Fuerte
Baja California	75	
Cajeme	32	Yaqui
Durango	35	Mezquital
El Fuerte	59	Fuerte
Guaymas	272	Gulf of California
Hermosillo	32	Sonora
Mazatlan	40	Gulf of California
Tijuana	307	Tijuana
Total for basin	893	
Basin: Caribbean		
Colombia		
Barranquilla	74	Magdalena
Bogota	66	Bogota
Cartagena	102	Caribbean Sea
Honda	155	Magdalena
Yumbo	53	Cauca
Zupaguria	71	Bogota
Subtotal	624	
Costa Rica		
Heredia	31	Grande de Tarcoles
Subtotal	31	
Total for basin	655	
Basin: Central Chile		
Chile		
Coronel	125	Pacific Ocean
Laguna Verde	55	Pacific Ocean
Laja	33	Laja
Santiago	100	Mapocho
Ventanas	115	Pacific Ocean
Total for basin	428	
Basin: Gulf of Mexico		
Mexico		
Altamira	316	Altamira Lagoon
Tampico	29	Gulf of Mexico
Total for basin	345	

Annex 6 (cont.17)

Location of the plant	Capacity (MW)	Water body
Basin: Interior of Argentina		
Argentina		
Dean Funes	33	
La Banda	18	Dulce
Pilar	141	Segundo
Tucuman	80	Sali
Total for basin	272	
Basin: North Pacific		
Mexico		
Celaya	43	Lerma
Guadalajara	87	Santiago
Salamanca	322	Lerma
Total for basin	452	
Basin: Orinoco		
Colombia		
Belencito	25	Chicamocha
Paipa	99	Grande
Total for basin	124	
Basin: Pampa		
Argentina		
Bahia Blanca	50	Atlantic Ocean
Lujan de Cuyo	120	Mendoza
Mar de Ajo	16	Atlantic Ocean
Necochea	206	Atlantic Ocean
Neuquen	30	Neuquen
Total for basin	422	
Basin: Patagonia		
Argentina		
Comodoro Rivadavia	47	Atlantic Ocean
Total for basin	47	
Basin: Plata		
Argentina		
Atucha	370	Parana
Avellaneda	184	La Plata
Barranqueras	55	Parana
Bragado	12	Salado
Buenos Aires	2 845	La Plata
Caseros	19	Uruguay
Chascomus	3	Salado
Concepcion del Uruguay	15	Uruguay
Corrientes	175	Parana
Guemes	120	San Francisco
Gutierrez	17	La Plata
Junin	16	Salado
La Tablada	54	La Plata
Malaver	36	La Plata
Moron	36	La Plata
Olavarria	32	Tapalquen
Palpala	36	San Francisco
Parana	22	Parana
Pehuajo	12	
Posadas	48	Parana
Reconquista	3	Parana
Resistencia	108	Parana
Rio Cuarto	3	Cuarto

Annex 6 (cont.18)

Location of the plant	Capacity (MW)	Water body
Basin: Plata		
<u>Argentina</u> (cont.)		
Rio Tercero	644	Tercero
Roque Saenz P.	17	
Rosario	226	Parana
Salta	32	San Francisco
San Nicolas	720	Parana
San Pedro	8	San Francisco
Santa Fe	37	Salado
Tartagal	13	Itiyuro
Villa Maria	51	Tercero
Subtotal	6 065	
<u>Brazil</u>		
Alegrete	66	Ibirapuita
Bage	446	Negro
Campinas	30	Piracicaba
Cariova	30	Das Antas
Sao Roque	450	Tiete
Tubarao	255	Palmeiras
Subtotal	1 277	
<u>Uruguay</u>		
Montevideo	280	Atlantic Ocean
Subtotal	280	
Total for basin	7 622	
Basin: Rio Bravo		
<u>Mexico</u>		
Chihuahua	76	Chuviscar
Delicias	66	San Pedro
Francisco I Madero	30	Manantial Cabecera
Monterrey	161	Pesqueria
	30	Pesqueria
Nava	38	
Rio Bravo	75	Nazas
San Nicolas	393	Pantano
Total for basin	869	
Basin: South Atlantic		
<u>Brazil</u>		
Campos	30	Paraiba Do Sul
Duque de Caxias	23	Niteroi
Porto Alegre	24	Guaiba
Salvador	20	Atlantic Ocean
Santa Cruz	599	Sepetiba Bay
Sao Geronimo	92	Jacui
Sao Goncalo	33	Guanabara Bay
Total for basin	821	
Basin: Southern Interior		
<u>Mexico</u>		
Gomez Palacio	189	Nazas
Torreon	28	Nazas
Total for basin	217	

Annex 6 (concl.)

Location of the plant	Capacity (MW)	Water body
Basin: Tropical Pacific		
Costa Rica		
San Jose	20	Torres
Subtotal	20	
Ecuador		
Cumbaya	23	San Pedro
Ximena	110	Guayas
Subtotal	133	
El Salvador		
Acajutla	70	Pacific Ocean
Soyopango	59	Acelhuate
Subtotal	129	
Guatemala		
Escuintla	58	Michatoya
La Laguna	30	Maria Linda
Subtotal	88	
Total for basin	370	
GRAND TOTAL	14 072	

Source: Various national sources.

Annex 7

LATIN AMERICA AND THE CARIBBEAN: MINING PRODUCTION, BY MINERALS, COUNTRIES AND YEARS

Country	1950	1970	1980	1985
ANTIMONY (tons)				
Argentina		0.3		
Bolivia	8 781.0	11 576.0	15 465.0	8 635.0
Guatemala		261.0	556.0	90.0
Honduras		342.9	28.0	320.0
Mexico	5 868.0	4 468.0	2 176.0	3 574.0
Peru	970.6	1 167.0	655.0	263.0
Total	15 619.6	17 815.2	18 880.0	12 882.0
ARSENIC (tons)				
Brazil	1 066.8	298.0		
Mexico	8 986.5	9 140.0	6 932.0	5 000.0
Peru		772.0	2 475.0	800.0
Total	10 053.3	10 210.0	9 407.0	5 800.0
BAUXITE (1 000 tons)				
Brazil	18.6	509.8	4 152.4	6 433.2
Dominican Republic		1 086.0	510.5	
Guyana	1 668.4	4 417.2	3 052.0	2 484.7
Haití		656.8	461.0	
Jamaica		12 009.7	12 064.3	6 239.3
Suriname	2 045.4	6 022.0	4 903.1	3 374.8
Total	3 732.4	24 701.5	25 143.3	18 532.0
BERYLLIUM (tons)				
Argentina		571.0	31.0	15.4
Brazil	2 894.0	3 333.0	550.0	1 496.8
Total	2 894.0	3 904.0	581.0	1 512.2
BISMUTH (tons)				
Bolivia	24.4	623.0	11.0	125.6
Mexico	263.2	571.0	770.0	385.0
Peru	226.9	806.2	490.0	362.6
Total	514.5	2 000.2	1 271.0	873.2
CHROMIUM (1 000 tons)				
Brazil	2.0	27.9	316.9	250.0
Cuba	1.5	8.0	10.0	10.0
Total	3.5	35.9	326.9	260.0
COAL (1 000 tons)				
Argentina	26.0	615.5	389.0	396.0
Brazil	1 959.0	2 361.3	4 984.6	7 178.0a/
Colombia	1 010.0	2 500.0	4 113.0	9 706.0
Chile	1 995.0	1 382.4	995.6	1 369.8
Mexico	1 000.0	2 959.2	6 827.5	9 770.8
Peru	195.7	156.1	85.0b/	85.0b/
Venezuela	1.4	40.0	48.0	36.0
Total	6 187.1	10 014.5	17 442.7	28 541.6

Annex 7 (cont.1)

Country	1950	1970	1980	1985
COPPER (1 000 tons)				
Argentina		0.5	0.2	0.1
Bolivia	4.7	8.9	1.7	2.4
Brazil		3.8	0.4	32.0
Chile	362.9	691.6	1 067.9	1 356.4
Colombia		0.1	1.4	0.2
Cuba	20.4	0.4	3.3	3.0
Dominican Republic		0.4		
Ecuador	0.5	0.2	0.9	
Guatemala			0.8	
Haiti		4.8		
Mexico	61.7	61.0	175.4	173.0
Nicaragua		3.4		
Peru	30.1	220.2	366.7	386.8
Total	480.3	995.3	1 618.7	1 953.9
GOLD (kilograms)				
Argentina	248.8		330.4	699.8
Bolivia	240.0	951.9	1 619.7	933.1
Brazil	6 080.7	5 329.0	40 434.0	62 207.0
Chile	5 984.0	1 622.9	6 835.7	17 240.1
Colombia	11 801.0	6 267.9	15 876.4	35 769.0
Costa Rica	3.6	15.6	559.9	1 088.6
Dominican Republic	14.8		11 495.9	10 486.5
Ecuador	2 998.5	265.0	7.0	31.1
El Salvador	903.6	71.6	77.5	8.7
Guyana	384.6	137.9	342.2	321.1
Honduras	1 136.7	103.7	63.0	77.8
Haiti		93.3	90.0	90.0
Mexico	12 694.0	6 166.0	5 476.9	8 864.5
Nicaragua	7 129.1	3 582.3	1 866.0	761.8
Peru	3 964.4	3 349.0	4 417.9	6 950.0
Suriname	143.4	35.4	10.9	15.6
Venezuela	1 071.9	694.2	421.9	2 267.4
Total	54 799.1	28 685.7	89 925.3	147 812.1
IRON (1 000 tons)				
Argentina	40.0	238.8	412.0	578.0
Bolivia		4.1	6.0	7.0
Brazil	1 987.0	40 233.6	100 275.0	114 695.0
Chile	2 975.9	11 265.0	8 960.0	6 534.0
Colombia		453.0	491.0	440.0
Guatemala		2.0		
Mexico	419.6	4 353.6	8 149.0	8 103.0
Peru		9 711.9	5 679.0	4 892.0
Venezuela	198.1	22 099.0	13 681.0	14 710.0
Total	5 620.6	88 361.0	137 653.0	149 959.0
LEAD (1 000 tons)				
Argentina	23.0	35.6	32.6	29.0
Bolivia	31.2	25.8	15.9	7.8
Brazil		20.3	21.8	19.2
Chile	3.3	0.9	0.5	2.7
Colombia		0.5	0.1	
Ecuador	0.2	0.1	0.2	0.2
Guatemala	3.0	1.0	0.1	0.1
Honduras	0.3	15.1	13.3	20.4
Mexico	238.1	176.6	147.2	181.6
Peru	62.1	156.8	189.1	216.2
Total	361.2	432.7	420.8	477.2

Annex 7 (cont.2)

Country	1950	1970	1980	1985
MANGANESE (1 000 tons)				
Argentina		10.2	1.4	0.3
Bolivia		0.1	1.4	
Brazil	86.0	1 201.9	1 339.0	1 056.7
Chile	16.7	11.1	9.0	0.5
Colombia		0.5	21.4	20.0
Cuba	11.6	20.0		
Mexico	14.5	98.6	161.0	192.5
Peru	0.5	0.6		
Total	129.3	1 343.0	1 533.2	1 270.0
MERCURY (tons)				
Chile	11.0	13.4		
Colombia		7.4		
Dominican Republic			5.5	0.7
Mexico	128.0	1 043.0	145.0	344.7
Peru		110.2		
Total	139.0	1 174.0	150.5	345.4
MOLYBDENUM (tons)				
Chile	992.0	5 701.2	13 668.0	18 390.0
Mexico		141.1	73.9	3 696.8
Peru	0.9	606.9	2 688.0	3 827.9
Total	992.9	6 449.2	16 429.9	25 914.7
NICKEL (tons)				
Brazil		2 990.0	4 291.0	13 200.0
Colombia				14 000.0
Cuba		36 775.7	38 230.0	38 000.0
Dominican Republic			15 500.0	25 400.0
Guatemala			6 900.0	
Mexico		44.0	18.1	
Total		39 809.7	64 939.1	90 600.0
OIL (1 000 m^3)				
Argentina	3 728.8	22 793.2	28 566.0	26 716.2
Bolivia	98.0	1 402.2	1 383.9	1 140.0
Brazil	53.9	9 685.6	10 562.0	31 716.3
Chile	100.2	1 976.5	1 933.1	2 074.4
Colombia	5 414.4	12 725.5	7 303.7	10 239.0
Cuba	2.1	167.4	288.0	913.2
Ecuador	418.4	235.3	11 890.4	16 279.9
Mexico	11 746.0	29 132.0	122 822.0	159 263.0
Peru	2 388.9	4 176.0	11 345.4	10 935.1
Trinidad and Tobago	3 285.5	8 114.3	12 340.9	10 247.0
Venezuela	86 929.0	215 177.0	125 737.0	97 539.8
Total	114 165.2	305 585.0	334 172.4	367 063.9
PLATINUM (kilograms)				
Colombia	760.5	808.7	446.2	362.3
Total	760.5	808.7	446.2	362.3
SALTPETER (1 000 tons)				
Chile	1 659.7	674.1	620.4	700.0
Total	1 659.7	674.1	620.4	700.0

Annex 7 (cont.3)

Country	1950	1970	1980	1985
SELENIUM (tons)				
Chile			17.0	25.0
Mexico		126.0	46.0	40.0
Peru		7.0	23.0	22.0
Total		133.0	86.0	87.0
SILVER (tons)				
Argentina		87.6	73.3	61.5
Bolivia		185.6	189.7	125.0
Brazil	0.7	12.0	44.5	66.5
Chile	37.2	76.2	298.5	505.0
Colombia	3.6	2.4	4.1	6.1
Dominican Republic			60.5	46.5
Ecuador	8.0	2.2	1.0	
El Salvador	-	4.8	4.8	0.6
Honduras	109.3	118.7	53.5	80.7
Haiti		0.5	0.6	0.7
Mexico	1 528.5	1 332.4	1 556.8	2 158.8
Nicaragua	4.1	6.7	5.1	1.5
Peru	417.8	1 239.0	1 339.8	1 769.8
Total	2 109.2	3 068.1	3 632.2	4 822.7
SULPHUR (1 000 tons)				
Argentina	7.7	40.0		10.0
Bolivia	7.8	16.0	11.0	2.0
Brazil		9.0	156.0	337.0
Chile	15.4	109.0	115.0	109.5
Colombia	1.2	34.0	27.0	38.0
Cuba			30.0	8.0
Ecuador		6.1	14.0	14.0
Mexico	11.2	1 381.0	2 217.0	2 190.0
Trinidad and Tobago		4.4	57.0	5.0
Total	43.3	1 599.5	2 627.0	2 713.5
TIN (tons)				
Argentina	261.0	1 172.0	600.0	270.0
Bolivia	31 712.0	30 100.0	27 271.0	18 000.0
Brazil	183.0	3 680.0	6 930.0	22 000.0
Mexico	447.0	533.0	60.0	400.0
Peru	38.2	102.9	1 077.0	3 807.0
Total	32 641.2	35 587.9	35 938.0	44 477.0
WOLFRAM (tons)				
Argentina	23.6	143.8	44.0	36.0
Bolivia	2 484.8	1 845.2	2 732.0	1 551.0
Brazil	1 371.7	1 156.2	1 116.0	1 175.0
Guatemala		40.8		
Mexico	67.9	288.0	265.8	291.0
Peru	516.2	804.2	581.0	870.0
Total	4 464.2	4 278.2	4 738.8	3 923.0

Annex 7 (concl.)

Country	1950	1970	1980	1985
ZINC (1 000 tons)				
Argentina	12.6	39.0	33.7	36.0
Bolivia	19.6	46.5	46.2	41.0
Brazil		11.0	70.0	110.0
Chile	0.1	1.5	1.1	18.0
Colombia		0.2	0.3	1.0
Ecuador		0.1	0.6	0.1
Guatemala	0.3	1.0	0.1	
Honduras	0.1	18.6	16.0	44.0
Mexico	223.5	266.4	235.8	280.0
Nicaragua				
Peru	88.0	299.0	530.8	588.6
Total	344.2	683.3	934.6	1 118.7

Source: ECLAC, "Estadísticas mineras: producción y precios en América Latina y el Caribe" (LC/R.545), 18 March 1987.

a/ 1984.
b/ 1979.

Annex 8

LATIN AMERICA AND THE CARIBBEAN: AGRICULTURAL CHEMICALS WHOSE CONSUMPTION AND/OR SALE HAVE BEEN BANNED, WITHDRAWN, SEVERELY RESTRICTED OR NOT APPROVED BY GOVERNMENTS

A G R I C U L T U R A L C H E M I C A L S	LATIN AMERICA & THE CARIBBEAN	
	C O U N T R Y	EFFECTIVE DATE a/
1. alpha-HCH	Argentina	2 October 1980
2. beta-HCH	Argentina	2 October 1980
3. delta-HCH	Argentina	2 October 1980
4. gamma-HCH	Argentina	20 December 1971
	Argentina	1 June 1972
	Colombia	May 1978
	Ecuador	1985
5. ALDRIN	Argentina	19 March 1963
	Argentina	30 April 1968
	Argentina	20 December 1971
	Argentina	1 June 1972
	Chile	5 January 1983
	Colombia	6 December 1974
	Ecuador	1985
	Venezuela	6 June 1983
6. AMITRAZ	Argentina	24 June 1980
7. AMITROLE	Ecuador	1985
8. ARAMITE	Argentina	20 December 1971
9. ARSENIC	Ecuador	1985
10. CAMPHECHLOR	Colombia	December 1974
	Ecuador	1985
	Venezuela	1983
11. CHLORDANE	Argentina	1 June 1972
	Argentina	10 June 1969
	Chile	5 January 1983
	Colombia	6 December 1974
	Ecuador	1985
	Venezuela	1983
12. CHLORDECONE	Venezuela	1983
13. CHLORDIMEFORM	Colombia	19 July 1978
	Ecuador	1985
	Guatemala	April 1978
14. CHLOROBENZILATE	Ecuador	
15. DDT	Argentina	19 March 1963
	Argentina	30 April 1968
	Argentina	20 December 1971
	Argentina	1 June 1972
	Chile	1 January 1985
	Colombia	2 May 1977
	Colombia	12 May 1978
	Colombia	6 December 1974
	Cuba	1970
	Ecuador	1985
	Ecuador	1985
	Guatemala	April 1980
	Venezuela	1983

Annex 8 (cont.1)

AGRICULTURAL CHEMICALS	LATIN AMERICA & THE CARIBBEAN	
	COUNTRY	EFFECTIVE DATE a/
16. DIELDRIN	Argentina	21 February 1968
	Argentina	27 March 1969
	Chile	5 January 1983
	Colombia	6 December 1974
	Ecuador	1985
	Venezuela	1983
17. DINOSEB	Ecuador	1985
18. ENDOSULFAN	Argentina	1 May 1968
	Argentina	1 June 1972
19. ENDRIN	Argentina	19 March 1963
	Argentina	1 May 1968
	Argentina	10 June 1969
	Argentina	20 December 1971
	Argentina	1 June 1972
	Chile	5 January 1983
	Colombia	September 1985
	Ecuador	
	Venezuela	1983
20. ETHYLENE DIBROMIDE (EDB)	Chile	7 February 1985
	Colombia	15 May 1985
	Ecuador	1985
21. HCH-MIXED ISOMERS	Argentina	2 October 1980
	Colombia	6 December 1974
	Colombia	12 May 1978
	Ecuador	1985
22. HEPTACHLOR	Argentina	1 June 1972
	Argentina	21 February 1968
	Argentina	1 May 1968
	Argentina	10 June 1969
	Argentina	20 December 1971
	Chile	5 January 1983
	Ecuador	
	Venezuela	1983
23. HEXACHLOROBENZENE	Argentina	19 March 1963
	Argentina	30 April 1968
	Argentina	1 June 1972
24. ISOBENZAN	Colombia	December 1974
25. LEAD	Ecuador	1985
26. LEPTOPHOS	Colombia	5 July 1977
	Ecuador	
	Guatemala	October 1977
27. MALEIC HYDRAZIDE	Guatemala	
28. MELIPAX	Colombia	December 1974
29. MERCURY	Colombia	November 1974
30. METHOXYCHLOR	Argentina	19 March 1963
	Argentina	30 April 1968
	Argentina	1 May 1968
	Argentina	1 June 1972

Annex 8 (concl.)

AGRICULTURAL CHEMICALS	LATIN AMERICA & THE CARIBBEAN	
	COUNTRY	EFFECTIVE DATE a/
31. MIREX	Ecuador Venezuela	1985 1983
32. PARATHION	Ecuador	1985
33. PARATHION METHYL	Ecuador	1985
34. PENTACHLOROPHENOL	Ecuador	1985
35. PHENYLMERCURY ACETATE	Argentina	21 December 1971
36. SILVEX	Colombia Colombia	May 1979 18 May 1979
37. SODIUM FLUOROACETATE	Colombia	May 1969
38. SODIUM METHANEARSONATE	Argentina	20 December 1971
39. TRIFLURALINE	Guatemala	
40. 1,2-DIBROMO-3--CHLOROPRPPANE (DBCP)	Argentina Colombia Ecuador Guatemala	2 October 1980 February 1982 1985 October 1981
41. 2,4-D	Guatemala	July 1982
42. 2,4,5-T	Colombia Ecuador Guatemala	18 May 1979 1985

Source: Consolidated list of products whose consumption and/or sale have been banned, withdrawn, severely restricted or not approved by governments, Second issue, ST/ESA/192, United Nations, 1987, pp. 121-226.

a/ The effective date on which the regulation related to the use of the chemical in question came into force in the respective country.

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